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Journal of the

AMERICAN STATISTICAL ASSOCIATION

MARCH 1947

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American Statistical Association

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Incorporated 1841

The American Statistical Association is a scientific and educational organization. Its membership is not confined to professional statisticians but includes economists, business executives, research directors, government officials, university professors, and other persons who are seriously interested in the application of statistical methods to practical problems, in the development of more useful methods, and in the improvement of basic statistical data. Engineers, mathematicians, biologists, actuaries, sociologists, psychologists, and representatives of many other professions are included in the membership of the Association.

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JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION

Number 237 MARCH 1947 *Volume 42*

A TRIBUTE TO TWO PAST PRESIDENTS OF THE ASSOCIATION

THE American Statistical Association had the privilege of giving a testimonial dinner at its annual convention in Atlantic City to two great men who have been pioneers in advancing the status of statistics from the haphazard and empirical accumulation of data to an exact methodology of mathematical analysis. Although Past Presidents Irving Fisher and Walter Willcox have both passed their 80th birthdays, they remain young in spirit, creative in intellect, able to inspire their younger disciples, and endowed with exploratory minds which span broad ranges of social and mathematical sciences.

There is little I can add to the addresses in honor of these two eminent veterans—that of Ragnar Frisch on Irving Fisher, and that of E. Dana Durand on Walter Willcox, which are printed in the pages that follow.

Irving Fisher has been a pathbreaker in the application of mathematical thinking and clear mathematical prose to the complex problems of value, marginal utility, the rate of interest, and the use of index numbers in inter-temporal comparison. He has dredged new channels in economic and statistical thought which will doubtless influence the directions of discovery in the statistical-economic field for generations to come. He exemplifies that rare combination of rigorous thought and boldness of origination which is the crucial mixture necessary for creative scientific accomplishment on a grand scale.

Walter Willcox has been an outstanding leader in the fields of demography, teaching, and the application of statistical method to the problems of Government. Not the least of his accomplishments is his work in building an international statistical association, in which the scientific men of all countries can exchange ideas and join in a common creative purpose without regard to politics or national hatreds.

Each of these eminent men, in his own way, represents the best that America can offer to civilization. We regret only that the illness of Walter Steuart, another veteran of the statistical Grand Army, prevented his attending the testimonial dinner as one of our guests of honor.

I am sure that all members of the Association will wish to join me in hoping that these three men continue to enjoy many years of health and vitality, and to provide stimulus and leadership in the statistical field.

ISADOR LUBIN
Past President of the American Statistical Association

New York
March, 1947

TRIBUTE TO IRVING FISHER

RAGNAR FRISCH
University of Oslo

THIS is a great occasion in the life of a great man, Professor Irving Fisher, as, in these days he is eighty years old.

I know of no man who has such a broad range of interests as Professor Fisher, and who has to the same extent, been able to fill all of his lines of activity with life and permanent initiative. The most salient feature of his work is, I think, that in everything which he has been doing, he has been anywhere from a decade to two generations ahead of his time. He has indeed been a pioneer, and like all pioneers he has been shot at by the Indians. I am not sufficiently informed to be able to talk about all the aspects of the life of friend Fisher. To do this would take a large committee, but I know enough of the matter to be able to say that many of those developments that are now most significant in changing the terms of our daily life, have in some way or another been related to Fisher's initiative. In many cases they have been related to his initiative in a much more significant way than would appear from the official records, because so often he worked by indirect ways and means.

This applies, for instance, if I am correctly informed, to Fisher's connection with the establishment of the League of Nations, and its successor, the United Nations, in which the hope of a whole world now resides. Fisher's influence on these developments came about through his contacts directly and indirectly with Presidents Wilson and Franklin D. Roosevelt.

In the field of his scientific achievements where I, presumably, should be able to talk with more immediate knowledge, I will point out only two things. Of course, it is difficult to make a selection in his very extensive list of works. The statisticians would want to see included his book on index numbers, which has been so widely read, or his theory of distributed lags. But there are two other contributions which, in my view, are still more significant: namely, the crucial contribution he

made in his doctoral dissertation *Mathematical Investigations into the Theory of Value and Prices*, and the new light he shed on an old problem in his *Theory of Interest*.

Many of you, and perhaps Professor Fisher himself, may think of the *Theory of Interest* as his *magnum opus*. And there can be no doubt about the fact that this work was epoch making when it introduced into this field the equilibrium way of thinking, and the groping for a dynamic theory of value.

But in my view, his *Mathematical Investigations* is of even more monumental importance. I remember the intensity with which, in my younger days, I dug into Fisher's dissertation, and the same can undoubtedly be said about many other economists of our generation. Later, this work was followed up by his paper on the *Measurement of Marginal Utility*.

When we are speaking not about the ideas that cause the shorter swings, or even the sub-secular swings of the thinking in economics, but about those that are responsible for the really long-time trend of our science, then it will be hard to find any single work that has been more influential than Fisher's dissertation. It will be standing there as a milestone long after our great grandchildren are dead and forgotten.

Those of us who know Fisher from the inside will be aware of the fact that he puts quite a bit of energy in elaborating his explanations, so that people will be able to understand him. I think that several of those present may feel a bit uneasy when the conversation is brought to bear on how to speak in understandable terms. In this connection I would like to tell you about an episode that took place many years ago. Fisher and I had quite an argument over the way in which he presented his theory in that paper on utility measurement. I said that he should have condensed it to a few pages by a free use of a compact mathematical symbolism. That, I claimed, would have saved many of us a lot of time. But he would not give in to this argument. Then, some years later, I gave a series of lectures in Oslo, on utility axiomatics and the application of utility theory to the theory of demand. As the weeks passed by, I was greatly grieved by discovering that the audience dwindled down to nothing, when it finally became apparent that the students didn't understand a word of what I had been trying to tell them. Then one day one of the students came along and told me that in my collection of reprints—which is always at the disposal of the students—he had picked up Fisher's paper on utility measurement, and then it had suddenly dawned upon him what I had been trying to say. You may imagine the joy I got out of writing to friend Fisher and telling him of this story.

Now, I think that this is much more than a good story. It is symbolic of Fisher's ability to see clearly, and to stick to it in the midst of both friendly and adverse criticism. Many of those things in Fisher which we may, on the spur of the moment, be inclined to criticize, will, in the light of history, come down as one additional score to him.

When, after many years of separation, I saw Professor Fisher in New York about a week ago, I was happy to find that the brightness and intensity of his eyes, and also the twinkle in them, were just the same as they used to be, and his big, friendly and mellow heart was the same. In his characteristic, quiet, and yet intense way, he talked about mankind, and what could be done to improve the condition of his fellow citizens, economically, mentally, and from the viewpoint of health. World betterment in its most general and cordial sense, today, as it used to be, is the keynote of his thinking.

I am sure that the audience will join me in expressing the sincere hope that for many coming years he will be able to devote his energy and activity to this great cause.

RESPONSE OF IRVING FISHER

I AM SURE you will understand how great a pleasure it has been to be here tonight, and also how embarrassing it is to listen to all the sweet taffy which Professor Frisch has handed me. I will try to live up to what he said, but the trouble is that there does not seem to be enough time to approximate that. In fact, since next month I will be eighty, the taffy sounds a little like what has been called "epitaphy"—especially as a few weeks ago I received a letter forwarded from the Office of Yale University addressed to "The Successor to, or the Estate of, the late Professor Irving Fisher."

I replied, quoting Mark Twain, who when he read in the newspapers a report of his death, telegraphed the editor "Reports of my death greatly exaggerated."

It so happens that my first statistical publication was a monograph on Mortality Statistics. That was in 1899. This monograph incidentally was a critique on the accuracy of our American mortality statistics. At that time there were only a few states the statistics of which were regarded by the Federal Government as sufficiently accurate (within an estimated 10 per cent) to merit being recorded.

To illustrate how inaccurate these statistics were, and how innocent the public was as to the facts, I quoted from a report of the Board of Health of Iowa, which at that time was evidently a politically minded body. I may myself be inaccurate in my recollections of the figures. [Later: I have looked up the exact figures. The following is quoted

from my paper in the American Economic Association Monograph on The Federal Census (1899), pages 121–169.]

> "The *Monthly Bulletin* of the Iowa state board of health for June, 1890, presents in perfect seriousness the following death rates: in 1880, 16 per 1,000; in 1883, 3.7; in 1885, 4.5; in 1890, 4.0. The death rate for Dubuque is given as 9.3, for Des Moines, 0.8, and for Council Bluffs, 0.06. These figures are commented upon as follows: 'It was not till 1883 that the work of the state board of health began to be realized. The saving of lives, therefore, through the sanitary and protective measures of the state board, is a record to be proud of,' the fact being, of course, that the worthlessness of its statistics is a record to be ashamed of."

My own interest in statistics has not been primarily that of a statistician, but that of an economist, as indicated in the title of my address as President of the American Statistical Association in 1932, which was "Statistics in the Service of Economics."

That is, I have valued statistics as an instrument to help fulfill one of the great ambitions of my life, namely, to do what I could toward making economics into a genuine science.

TRIBUTE TO WALTER F. WILLCOX

E. Dana Durand
U. S. Tariff Commission

When I was asked to make tonight a few remarks concerning our honored guest, Walter Francis Willcox, I accepted with no little enthusiasm. I believe there are few men better able than myself to appraise him, and there is no man to whom I would rather show honor. My own career as a statistician took its birth in Willcox's classes at Cornell more than 50 years ago, and ever since I have been closely associated with him in many activities. He has been both my mentor and my very dear friend. I look upon him as the grand old man of our profession.

Willcox holds, or bids fair soon to hold, records in many directions. In the matter of longevity, he is close to holding the record amongst statisticians and economists, past and present. Age thus far has touched him so lightly that most of you members of the Association may readily live to see him reach the century mark. He comes near to holding the record, not merely among statisticians and economists but among the entire teaching profession, for length of service to a single university. Whether he taught anywhere before he entered Cornell in 1891—56 years ago—I do not know, but he has never since severed his connection with that great institution.

Willcox has indubitably shattered records for membership in scien-

tific, statistical, and economic organizations, for attendance at their sessions, and for the holding of high office in them. The list of the organizations—American, international, and foreign—of which he is a member readers like a roster of the world's important statistical associations. His membership, both in our own Association and in the American Economic Association, dates back to 1892; he is close to being the oldest living member of both; and he has probably attended more of their meetings than any other person, living or dead. He became President of the Statistical Association as long ago as 1912, and since the lamentable death of Frederick L. Hoffman last year, he has been the senior among our ex-presidents. He became President of the American Economic Association only 3 years later.

Willcox has since 1899 been a member of the International Statistical Institute. He is the oldest living American member of that highly selective and narrowly restricted organization. He has been by far the most faithful American attendant at the meetings of the Institute; he has skipped very few, if any, of them since his election. Bearing in mind that these meetings occur only at intervals of 2 or 3 years, and were long interrupted by each of the World Wars, the fact that he has attended 12 of them is remarkable; he was even at Prague in 1938 when the session there was interrupted by Hitler's invasion of Czechoslovakia. Moreover, Willcox has been one of the most constructive members of the International Institute. He has been active constantly in efforts to reform its constitution and to make it more useful to the world. He has been one of its Vice Presidents since 1923, and as such has attended numerous meetings of the "Bureau," the governing board of the Institute.

Willcox was one of the small group which a few years ago presided at the birth of the Inter American Statistical Institute, that daughter of the International Institute who may outdo her parent in public service unless said parent soon recovers from the shock of war. Incidentally here tribute should be paid to Stuart A. Rice and Halbert L. Dunn for their splendid service to his new Institute.

One of the most significant aspects of Willcox's career is the extent to which he has been able to coordinate teaching and private research with Government service. This combination of functions is becoming increasingly common and important throughout the physical and social sciences. It reached an extraordinary peak during the late war, being perhaps most conspicuous in connection with work on what is proving to be the greatest of today's world headaches, the atom bomb. The practice was not formerly anything like so prevalent, and Willcox was one of the pioneers in it. As far back as 1899, while still continuing work at Cornell, he became the chief of the division of Revision and Results

of the Census, in which capacity he issued a thoroughgoing analysis of the population statistics of the Tenth Census. It was while in that position that he launched Joseph A. Hill, another of our ex-presidents, on his long career as the scientific head of the work of the Census Bureau. Later on for many years Willcox was a special agent of the Census Bureau, making important contributions to its work; he was also long representative of the American Economic Association in the Census Advisory Committee.

When Willcox started his career as a statistician, the number of persons in this country entitled to be called statisticians was but a small fraction of the number at present. Only a few universities gave courses in statistics; now such courses are legion. Moreover, in those early days mathematical statistical methods were but little developed; now they are the subject of a large part of the instruction and research in the statistical field. Willcox, like myself and many other older statisticians, while by no means belittling mathematical methods, still believe that common sense and logic, unaided, can accomplish much that is useful in the criticism and interpretation of statistical data. In any case, mathematics can contribute relatively little to the solution of such basic problems as organization for the collection of statistics, formulation of questionnaires, planning of methods of tabulation, especially those involving classification and cross-classification, and arrangement of statistical tables.

When Willcox began his work, the primary interest of most American as well as foreign statisticians was in demography, a field the fundamental importance of which is still universally recognized. We money-minded Americans have since gone in for mass production of economic statistics. No doubt this trend has contributed to national prosperity and progress, though as yet we can have no assurance that statistics can save us from the dire consequences of the business cycle. Willcox has stuck by his original guns. Demography is still his forte, and he has contributed perhaps more than any other American to this branch of science.

The long and fruitful activity of Walter Francis Willcox in statistics —in a great university, in the Federal service, and in international organizations—makes it eminently fitting that he should be one of the two guests of honor on this occasion.

RESPONSE OF WALTER F. WILLCOX

MY FIRST duty this evening is to thank this Association, which I joined before our President of tonight was born, for its testimonial, and my dear friend Durand for his tribute, both of which I feel to

be unearned. I venture, however, to follow an example set by Samuel Johnson nearly two centuries ago. He had reported to his club the famous compliment which King George had paid him. When a friend asked if he had answered, Johnson replied, "No, sir! When the King had said it, it was to be so. It was not for me to bandy civilities with my Sovereign." So I select from my meagre store of memories enough to occupy the few moments by which I may delay our hearing the message of our president.

The first are a precipitate from the paper on the founder of our society, Lemuel Shattuck, which I read seven years ago at our centenary meeting. Beginning about 1830, a spate of statistical societies sprang up, a dozen or more in various cities of Europe and three at least in America. The American three were the Mexican Society of Geography and Statistics founded in 1833, the New York Statistical Society for which the legislature passed two laws in 1836 and 1839 but which never came to birth, and our statistical society which should properly have been named the Boston Statistical Society but which by a wise prescience, probably due to Shattuck, was baptized The American Statistical Association, not as was at first proposed, the American Statistical Society, for fear that the initials of that name might laugh it into its grave. But the constitutional provision that the annual meeting should be held in Boston suggests a struggle between a fact and a dream. The fact was that in 1839 no trace of an interest in statistics has been found in the country outside of Massachusetts and very little outside of Shattuck and the group which he inspired. The dream, probably also Shattuck's, was that some day his life long devotion to statistics as an instrument for improving man's estate might be shared by folk the country over, a dream now realized as this gathering and many others like it clearly show.

This sudden sprouting of an interest in statistics more than a century ago at scattered points in the western world suggests two questions:

1. Why the sudden efflorescence? and
2. Why did most of these societies die a-borning and why did two reach maturity and international importance?

I have not sought to explore the elusive evidence for an answer. That I leave for a successor who will write, I hope, a much needed history of statistics; at present only a few fragmentary and long out-dated essays exist. This evening I offer an hypothesis for a successor to test.

Two factors were noteworthy among those which contributed to this blossoming of statistical societies, one personal, the other general. The general factor was the liberalizing of opinion in the western world dur-

ing the 1830's and the spreading belief that scientific methods might be extended into the field of social and economic studies. On that factor I have no special competence to enlarge. The personal factor was Quetelet who was probably the most influential statist of the last century. He was certainly an important and probably the most active agent in founding, first, the statistical section of the British Association for the Advancement of Science and, later, the London Statistical Society. He was also a friend of Shattuck, the man who almost single handed founded our society.

That the Statistical Society of London had better prospects of survival than a similar society in any lesser city needs no proof. At its jubilee meeting it became the Royal Statistical Society with the added prestige carried by the adjective. That ours was the only other one of these statistical societies to become national and then international in importance may also be due in large measure to two factors, one personal and the other accidental. The accidental factor, and by that I mean one the cause of which is unknown, was that it alone among the entire group adopted a national and not an urban name. It was nevertheless essentially a Boston Statistical Society as appears from the list of its early members, the nature of the papers read before it, and the fact that for more than fifty years its constitution required the annual meeting to be held in Boston. We may conjecture that the word American was chosen by Shattuck in the hope that American interest in statistics almost confined a century ago to the vicinity of Boston would one day become nation wide or even hemisphere wide and that an American Statistical Association would by its very name have preempted the field.

At this point in the history of the Association my connection with it began. During the 1890's it had fallen on evil days and that although Francis Walker presided over the society regularly until his death in 1897 and thereafter Carroll Wright until his death in 1909. At that time I journeyed to Boston on several occasions to attend the annual meeting, but never found more than a dozen members present. When the society voted unanimously at my suggestion to strike out the provision requiring such meetings to be held in Boston, only six votes were cast. The society then became peripatetic, affiliated with cognate societies and soon began to revive.

Another chain of memories recalled by Dr. Durand's words may be mentioned, even though the effort ended in failure. Had it not been for the war our centenary seven years ago would have been graced by the presence of many members of the International Statistical Institute as

our guests and those of the government. At the London centenary of the Royal Statistical Society in 1934 the Institute, which had originated during the jubilee meeting of that society fifty years before, was a guest. On that occasion the president was a German and his imperfect command of spoken French and spoken English, due perhaps in part to his yielding to the pressure of the German government to use its language at international gatherings, had proved a handicap. The president had exposed himself to criticism also by falling in with the anti-Semitic trend noticeable in Germany even as early as 1934. The American members of the Institute who were at London were planning for the centenary of this society five years later and expected to invite the Institute to be its guest. The leader of the London centenary celebration, Sir Josiah Stamp, made a deep impression on us all. Besides being perhaps the first economist and statist in England, he was outstanding as a speaker and presiding officer and ideally qualified to strengthen the position of the Institute before the public. This situation led us to try to make him President of the Institute before 1939. The first step, selecting him as a member of the Bureau or Executive Committee, was taken two years later at Athens when Professor Bowley resigned as treasurer and Sir Josiah succeeded him.

But at this point Hitler intervened to wreck our plan, first in 1938 by threatening to bomb Prague, a threat which ended the session in that city before new officers could be elected, and then later by drowning Sir Josiah while he was at work near London in a bomb-proof shelter which unhappily was no protection against the flood from a shattered water main. This Association expects to entertain the Institute at Washington next September, but alas the leader we had hoped to greet will be only a memory.

One more reminiscence and I am done. In the winter of 1880–81 a small group of undergraduates at Amherst College were gathered in a dormitory room to find amusement in the forecasts of an itinerant phrenologist. In a dark corner sat a shy youngster already classed by his mates as a "dig"; he was doubtless his mother's darling and the village pride. The phrenologist after he had felt his bumps, said, "You seem frail, young man; I cannot promise you a long life, but I can promise that if you live long enough you will be very distinguished." As the aspiring innocent gasped out, "Distinguished for what?" the phrenologist brought him to earth with a cold "Distinguished for your great age."

SOCIAL AND ECONOMIC ADJUSTMENTS IN A DEMOCRATIC WORLD*

ISADOR LUBIN
Confidential Reports, Inc.

THE YEAR, just passed, will no doubt go down as one of the most significant, thus far, in statistical history. It will be remembered by this generation of statisticians, not so much because of the value and importance of the output of statistical material, but rather by the fact that figures—statistical data—were the central point of economic and social controversy through the greater part of the year.

Indeed, the battle of statistics was well under way before the year 1946 began. It came to the forefront in the automobile wage controversy; in the contention of the Automobile Workers Union that wage rates could be raised by a certain amount without necessarily increasing the cost of cars to the public. When this contention was denied and the union undertook to modify its demands, if management could prove by actual evidence that the wage increase could not be granted without an appreciable rise in production costs and hence in the price of its products, management, according to press dispatches, stood by its constitutional rights to refuse to make such data available. There followed one of the longest and costliest strikes in the annals of the automobile industry, a strike that was finally resolved after granting a wage increase of fairly considerable proportions.

It is not intended here to question the right of management, as reported in the press, to refuse to reveal the details of its costs. That is an issue of public policy that is an integral part of our concept of the nature of private rights, and our concept of under what conditions an industry comes within what has been defined as a public utility. Nor are we here concerned with the circumstances or the manner in which an agency of the federal government concluded that an increase of 19½ cents was justifiable. Nor are we concerned with the circumstances that finally led the management to grant the increase it made. What we are concerned with is the fact that we, you and I, do not know, and perhaps never will know, whether wages could have been increased 25 cents, 18½ cents, 16 cents, or even 10 cents, without appreciably raising the labor cost of making automobiles—had the controversy been amicably settled with-

* Presidential Address delivered at the Annual Meeting of the American Statistical Association on January 25, 1947.

out a shutdown, and had car production been continued through the period that the strike was in effect.

Judging by the profit and loss sheets of all of those involved—the corporation, the workers who were out on strike and the purchasing public—everybody lost in that first skirmish of the 1946 battle of statistics.

The repercussions of the battle, incidentally, even permeated the staid and solemn precincts of this Association, as those who were present at our meeting in Cleveland last year will so well remember.

A second important phase of the battle of statistics came to its fruition during the early months of the past summer, when a small but politically powerful group in the ranks of labor succeeded in stopping a certain appointment to one of the most important statistical offices in the federal government. The crime that the individual concerned was guilty of was that he had refused to yield to pressure to change a tried and tested method of compiling an index of the cost of consumers goods. The index was being used by the War Labor Board for wage determination purposes. To be sure, a logical case could have been made against using that particular index for that particular purpose. Having failed in their attempt to eliminate the use of the index by the War Labor Board in wage determinations, certain representatives of labor undertook to discredit the scientific validity of the index itself. The fact that two committees of the most competent persons in the field of index numbers, after careful and painstaking investigation, had placed its stamp of approval on the quality of data and the methods used in constructing the index, was of no moment. The fact that one of the committees had found that even after making allowances for certain factors that had been the basis of criticism on labor's part, the probable error in the index was not more than five percentage points in a total of 130 and had concluded that the index was a highly legitimate instrument for doing what it was set up to do—that is, measure changes in prices of what the mass of consumers buy—was of no concern.

A competent government official had dared answer unjustified charges of statistical incompetency. For that, this official was no longer to be permitted to retain the leadership of a federal statistical agency whose product plays an important part in decisions and negotiations in almost every phase of our domestic economy.

More recently, other statistical skirmishes have occurred involving labor productivity and the public ownership of electric power. At the present moment the battle still rages over the so-called Nathan report.

Time does not permit me to go into the details of the issues involved in these controversies. Suffice it to say that in the case of labor productivity statistics certain employers have used published government figures to prove that the lag in the production of certain commodities is attributable to the lack of cooperation and inefficiency on the part of labor. The fact that labor is but one factor in the productive process and that the output per man or per man hour is a function of the supply of materials and parts that are made available by management has apparently been overlooked in the argument.

The issue was simple. Government figures showed that the output per man hour in certain industries is lower than before the war. Labor is therefore responsible for the failure of production in particular lines of consumer goods to reach higher levels.

Such misuse of statistical data, or shall I say, the use of certain statistics for purposes for which they are not applicable, has in turn led to an attack upon the validity and integrity of the statistics themselves. In this particular instance charges have been publicly made by the representatives of a certain labor organization to the effect that the figures are unrepresentative and misleading and give a false picture of the trend in the productivity of labor. The fact that the output of workers in certain industries has fallen as compared with prewar years, a fact that any honest analysis of productivity figures could not avoid revealing, irrespective of the causes, many of which are outside the control of labor, appears to be beside the point. Government data were being used by employers as the basis of certain charges against labor. Accordingly, they must be made to appear untrustworthy. In the opinion of some, their collection and publication should even be suppressed.

Many of you have no doubt followed the recent controversy in the field of public ownership of electric power. In this instance a responsible trade association, by skillful manipulation of statistical and accounting data, undertook publicly to prove that the cost of generating electricity by the TVA compared unfavorably with the costs in privately operated plants. By including the cost of all sorts of extraneous factors, entirely unrelated to the generation of TVA power, costs which would have to be incurred for soil conservation, flood control, and navigation, even though the TVA did not generate a single horsepower of electricity, the trade association in question made a very persuasive case.

In the famous Nathan controversy the battle waged all the way from how much Nathan received from the CIO for preparing his report, to whether labor is receiving more real wages today than before the War. Little light has been thrown upon the validity of the data he has used,

the assumptions he has made, and the justification of arriving at the conclusions he reached from the data that were available. As far as I can see, the fundamental issue that Nathan raised, namely, can the output of consumers goods, at present or expected production rates, be absorbed by our economy in 1947, without either lowering prices or increasing the earnings of labor, seems to have been entirely overlooked.

To many of you the various instances that I have here mentioned may appear to be mere passing phases of a difficult reconstruction era. Personally, I am convinced that they are the more permanent symptoms of a maturing democracy, one of whose outstanding features is the growth in the number and power of pressure groups.

The American people, every section of our population, now knows how to read and write. And if they can't, they can listen to the radio. Able and efficient statistical analysts, and in some instances able manipulators of statistics, are available to all who wish to use them. Statistical departments are no longer a luxury solely within the resources of prosperous trade associations, large corporations, advertising agencies or government departments. They are an integral part of our farm organizations, our labor movement, indeed, of every organized group in our community. All of them are keenly aware of the potency of statistics as a tool for influencing public opinion and for obtaining the ends they seek. They may be relied upon to make every possible use of this tool.

During the coming year I believe we shall witness a still greater outpouring of statistical information and misinformation in the attempt to influence public policy by vested interests. The government of the United States is now embarking on a far reaching venture in international relations. It has accepted the postulate that rising standards of living through the world is one of the prerequisites of stable international relations. To this end it has committed itself to freeing and expanding the channels of world trade. This undertaking involves radical changes in our own trade policies. It involves the further implementation of our Reciprocal Trade Agreements, and a modification of our tariff policies along lines consistent with our position as a creditor nation.

Already the flood gates have opened. Statistical proof of the danger to the nation of any downward revision of particular tariff classifications has already started to flow from certain trade associations, from certain labor groups, from certain emissaries of agriculture. Rest assured that there will be no lack of statistics and facts to make it appear

that the private welfare of any group that feels that its economic position will be affected adversely, is synonymous with the public welfare and the maintenance of world peace.

This is not to say or even to imply that any group should be debarred from the right of petition or of a hearing. That right must remain an essential of our system of democratic government. Whether the ends sought by a particular group are in the public interest is for the people to decide for themselves.

In this concept, however, lies the implication of a public opinion sufficiently enlightened to make intelligent decisions on what is best for the public interest. This, in turn, implies that there is available to our legislators and to the public at large, not only such information as is pertinent to the issues involved but also authoritative and inbiased analyses of the facts.

Unfortunately, the statistical activities of the federal and state governments are still looked upon in many quarters as unnecessary and wasteful luxuries maintained at the taxpayers' expense, primarily to provide jobs for favorites. This attitude is particularly prevalent today when economy in government and the political advantage of tax reduction hold high priority in certain circles.

There is evidence from many directions of an oncoming attack upon "unnecessary" statistics. The collection of certain types of data that originated with the wartime activities of government has already been discontinued. Other types are on the way to being discontinued. Most of these data were essential to the intelligent wartime control of production, prices, inventories and wages, by the government. These government controls have now been abandoned. But has the elimination of such controls eliminated the need for adequate knowledge in these same fields, either by the government itself, or, more important, by industry, investors, farmers or labor? Can American business make intelligent decisions relative to its production program, its employment policies, or its price policies unless much of this same sort of information is available to it?

The American people, through their duly constituted representatives, have committed themselves to a policy of maintaining a high level of employment. Under our system of enterprise the successful implementation of that policy lies in large part in the decisions and activities of private business. Can private business make intelligent judgments with the type and quantity of statistical information now available to it, let alone what will be available if the present activities of the federal and state statistical agencies are curtailed as a result of budgetary cuts?

The known attitude toward expenditures for government statistical activities and the present temper of some of those who will have weight in determining the budgets of the federal statistical agencies makes it incumbent on all of us, users and producers of statistics alike, to make every effort to see that the financial needs of the statistical services are treated in a well considered and rational manner. It would indeed be well if the various appropriation committees could be persuaded to seek the advice of an impartial group from the statistical fraternity as to the probable effects upon the public interest of curtailing a given activity, before ordering budgetary cuts. The mere knowledge of the availability of such a group, officially constituted by a body such as this, would, I am convinced, lead to its being called upon for advice and guidance by certain enlightened members of some of the appropriation subcommittees.

And while dealing with the statistical activities of the federal government may I add that it would be well at this time once more to assess the methods employed by the more important agencies in collecting and preparing statistical data. It is some 12 years since a careful analysis has been made by an outside body of the methods and procedures of several of the larger federal statistical units. To that survey and the recommendation of those who took part in it must go a great part of the credit for the rise in the public acceptance of the product of at least one government bureau with which I have had some acquaintance. All of us who have had any experience either in the actual operation of Washington agencies or who have had occasion extensively to use their materials are conscious of many shortcomings and the need for considerable improvement in certain statistical areas.

I believe the time has come for the American Statistical Association to establish a permanent committee to advise on the entire field of statistical standards. Such a body could well be a part of its organizational structure. Briefly, its membership should be of such professional stature that its findings and recommendations will be accepted by workers in the fields of statistics and by the public at large. It should be available, upon request, to government bodies to review existing or proposed statistical undertakings and pass judgment and make recommendations relative to the standards employed. To this extent it would serve in the same capacity as the Committees on Government Statistics originally appointed by this Association in 1933. It should, however, also serve as a tribunal which would analyze and render opinions on controversial issues concerned with statistical procedures and with the presentation of statistical materials. In this capacity it

should be authorized, on its own initiative, as well as upon the request of responsible outside individuals or organizations, to investigate controversies which in its opinion merit its attention.

It should be evident that the existence of such a body would in no way preclude any member of the statistical fraternity from assuming the position of advocate in any issue which he might wish to sponsor or further. Should such a Committee on Standards obtain the public acceptance that a properly constituted body should eventually merit, its existence and reputation would merely be notice to such an advocate that in any matter of comparable public interest there might be an advantage in maintaining certain standards—whether the ends sought, be increases in wages, decreases in wages, higher prices or discrediting public ownership of electric power.

I am quite certain that to many of you who have had to deal with committees of Congress, the idea of expecting an orderly consideration of the statistical activities of the federal agencies by appropriation committees will appear to be in the realm of fantasy. Personally, I believe that there is a better chance of making a start toward that end in the year 1947 than most of us imagine. This is going to be a year of Congressional investigations—in many instances for the purpose of revealing the inefficiency and wastefulness in federal departments. Since investigations are going to be made anyway, why shouldn't we as members of the statistical fraternity work toward channelling them into constructive paths; so that the findings may lead to the advantageous revamping of statistical activities, improvements in quality and methodology, and greater uniformity?

Many of you will no doubt question the possible effectiveness of any body of this organization that undertook to pass judgment on the statistical standards of government and private agencies. Here I can only reply that the tremendous part played by statistical data in arriving at judgments and decisions affecting every phase of our democratic society imposes upon us the responsibility of making available a mechanism which will provide the means for subjecting statistics to certain standards. One need merely bear in mind the part played by public opinion polls in arriving at political and business judgments to realize the stake that we as professional statisticians have in a publicly recognized code of statistical standards.

* * *

Within a few months, two years will have passed since the defeat of the Nazi hordes. By good fortune we were spared the horrors of the

devastation that befell our allies. We emerged with our productive facilities not only intact, but in many instances greatly enhanced. We emerged also with a greatly reinforced concept of the dignity of man and the realization that we can no longer live isolated from the rest of the work if peace is to prevail.

Whether we like it or not the world is looking to us to help rebuild its shattered economies. It has no other place to look for help. Unless we accept our economic responsibilities in the international field, we will have only ourselves to blame if we find emerging throughout the world forms of government which are far different from what we had hoped to see grow out of the shambles of war.

If we are to achieve the objectives for which we made such great sacrifices during the war, if the dignity of the human being and the freedom of the individual is to be universally recognized, we have no alternative other than to make still more sacrifices. To those who will say that we have done as much as we can afford, my only reply is: There is no limit to what we can afford in order to insure the friendship of the world and the maintenance of our own system of democratic freedom and our system of private enterprise.

But we must realistically face the fact that our ability to meet our responsibilities, that is, contribute to the rehabilitation and reconstruction of other countries by direct expenditures and granting of credits, will be determined almost entirely by how intelligently we cope with our own economic and social problems. Unless business, agriculture, labor, and government accept their responsibility and have the statesmanship to make the adjustments necessary to maintain and to increase our national output and keep employment at high levels, not only shall we fail the adherents of democracy in other lands, but the very structure of democracy here at home will be threatened.

We in the United States cannot, during the next few years, run the risk of an economic collapse of any magnitude. The American system of free enterprise cannot shoulder another shock of the amplitude of the early '30's. Having seen what our economy can do when we are threatened in war, the American people will not complacently accept unemployment in terms of tens of millions or a radical lowering of their standard of living. They will demand reforms and changes which in their opinion will be conducive to the full realization of the potentialities of our economic machine and to employment for those who desire to work. And we can rest assured that there will be many of different political and philosophical stripe who will promise them the attainment of that end.

Nor will the peoples of other countries willingly accept the importation of depression and mass unemployment from the U. S., a result which must inevitably follow a depression of any magnitude here at home. The opponents of our system of democracy abroad are avidly looking to an economic collapse in the U. S. before this decade is over, as practical proof of the inability of capitalism regularly to maintain high levels of employment. With the pronounced drift to the left throughout the world we can hardly hope to enlist or maintain an ardent following for our way of life if we are unable to keep our economy on an expanding level. As has so well been said: "Freedom-loving people are turning to us not only for assistance—but as an example!"

Our ability to meet this responsibility, yes, this fundamental challenge, will to a large degree be determined by the availability and intelligent use of pertinent data bearing upon every phase of our economic and social structure. Never before have facts, figures, and intelligent economic judgments been as important as they will be during the years immediately before us. Never before has adequacy of data and statistical integrity been so essential. For never before in history have the stakes involved been so high!

THE UNITED STATES GOVERNMENT PROGRAM FOR STATISTICS

The following six papers were delivered at a session of the 105th Annual Meeting of the American Statistical Association held in Cleveland in January, 1946. William R. Leonard of the Bureau of the Budget served as chairman of the session and editor of these papers.

TRADE ASSOCIATIONS AND GOVERNMENT STATISTICS

EARL CONSTANTINE
National Association of Hosiery Manufacturers

IT HAS recently been my privilege to serve as chairman of a special committee of trade association executives, set up by the National Industrial Council, to examine the merits of H. R. 4781 under which the scope of the powers of the Bureau of the Census would be amended and enlarged. As the views of such committee were presented before the House Committee on Census only yesterday,[1] it would appear appropriate that I should give you on this occasion the substance of what we have recommended, namely:

(a) The proposal to make the Census of Manufactures quinquennial instead of biennial is a desirable one.

(b) The need for annual surveys of selected industries is recognized, provided such surveys are confined to those industries whose performances are significant to the general economy, and the pattern of the surveys is within that of a quinquennial census, so that such annual surveys become in a sense interim reports. Such annual surveys should confine themselves to the essential data of volume of production, volume in value of shipments, inventories of raw materials and finished products. The Bureau of the Census should have the power to require reporting on such surveys but should retain the right to use descretion as to the extent to which they apply such powers finally. The Bureau should avoid making annual surveys in any industries where there are now available from private or semi-private sources information of the character described above.

(c) On surveys of greater frequency than annual, mandatory reporting should not apply. The reporting should be voluntary. Also, no such survey should be made without the burden of proof resting on the Bureau of the Budget to satisfy itself that a representative segment of the industry to be surveyed requires the information and that such information will serve the public interest.

(d) All reports or presentations by the Bureau of the Census should be strictly factual and should avoid entrance into the field of appraisal or deductions.

(e) The proposal under discussion should provide that it shall terminate on

[1] This speech was delivered on January 26, 1946.

December 31, 1955. This would assure a review of its performance during a period of approximately ten years during which there will have been held two quinquennial censuses of manufactures and a sufficient number of other types of surveys of the character described above. It would permit an improvement of the legal requirements in the light of experience.

TRADE ASSOCIATION PRACTICE

A few observations should be made with reference to the improved practice among trade associations in the field of statistics. A growing number of trade associations have developed statistical services in recent years and the statistical practice of such services is naturally improving with time. The following points are worth observing with reference to trade association statistical services:

(1) The field surveyed almost invariably extends to the whole industry, and is not confined to members of the association.

(2) The trade association is in the best condition to keep up to date on all changes within its industry in the form of new companies, consolidations, discontinuance of operations, etc. Its statistical coverage therefore, is as complete as possible and takes into account changes of the character mentioned.

(3) The breakdown which a trade association can use in its statistical schedules can be "commercial" in character. By this I mean it is of the type and of the designation which the industry and its market uses.

(4) Because a trade association has its statistical service confined to its own field, it is in good position to set up operating mechanics which produce the earliest possible results. The element of time is very important because the value of statistics depend on their timely availability.

(5) A trade association can set up its reports on the basis of a "hundred per cent sample," using one or more of the accepted methods for estimating the performances of non-reporting units. Assuming that such estimates are carefully developed, the industry benefits by a "hundred per cent sample" report because otherwise it itself would figure out similar estimates and would do so without having at hand the yardstick which guides the association.

(6) The schedules of a trade association statistical system can be changed more frequently and more quickly than those of an official schedule. Also, the trade association is in better position to know when a change is necessary because of developments in the practice of the industry or in the demands of the market.

COOPERATION WITH GOVERNMENT

A very unusual, interesting and profitable mode of continuing cooperation between a government agency and industry has been developed during the last three years on the instance of the Bureau of the Budget. When the Bureau was given the responsibility to administer the Federal Reports Act of 1942, it invited each of seven of the lead-

ing business federations or country-wide business organizations to appoint two persons to an advisory committee to the Bureau of the Budget known as the Advisory Committee on Government Questionnaires.

The A.C.G.Q. has contributed very materially to the early and satisfactory functioning of the Federal Reports Act. It has been my privilege to serve on this committee from the beginning. The committee maintains a Secretary and staff financed by contributions from the aforementioned national bodies and from various trade associations. Its budget is necessarily modest because its requirements are limited. It is, however, in a position to function with the Bureau and to handle the many inquiries that come to it from industry. I have been impressed with the atmosphere created by the Bureau of the Budget within which the committee functions. From the beginning it was clear that the Bureau was seeking all possible free and constructive suggestions and aid. The thinking as well as the functioning of the committee has remained at a similarly high level. This experiment in the field of everyday, frank, friendly and helpful cooperation between government and business inspires similar cooperative relations between other government agencies and the segments of business with which they deal.

THE FEDERAL TRADE COMMISSION'S CORPORATION REPORTS

WILLIAM H. ENGLAND
Federal Trade Commission

IN APRIL 1938, President Roosevelt, anticipating the government's early need for financial information covering a large number of industries, asked the Federal Trade Commission to begin the collection of information on investment, costs, and profits authorized in the act creating the Federal Trade Commission. There was some delay in launching the project pending a study by the Central Statistical Board. Finally, in 1939, as a result of this request, the Commission began its Corporation Reports project on a limited scale. It was continued in 1940 for a larger number of corporations, but in 1941, after the Office of Price Administration obtained war-time authority, similar to the peace-time authority of the Federal Trade Commission, the Commission's project was temporarily interrupted. With the end of the war, however, it was decided that the series begun in 1939 should be reestablished with the Federal Trade Commission and the Securities and Exchange Commission primarily responsible for an integrated system of reports.

WHAT DO THE CORPORATION REPORTS SHOW?

On the Pennsylvania Avenue side of the Archives Building in Washington, there is inscribed: "What is Past is Prologue." In corporation statistics for the vast majority of corporations, the results of the last full year of operations normally afford the most accurate results available to judge the current year's operations. Until a corporation's books are closed at the year end, many items remain unadjusted. In the beginning, at least, the Government's financial information will be collected on an annual basis. The industry samples will include large, medium-sized, and small corporations. In many industries there is a vast difference in the costs of production, cost of distribution and profits of groups of corporations of different size. During the war years, for example, one of the smaller corporations in an industry utilized 100 per cent for war work, turned its capital over 11.33 times compared with 3.48 times for the largest corporation in the industry, thereby greatly reducing capital charges and overhead.

I have here the summary of the 1940 series of Corporation Reports. These reports covered 86 major and 7 sub-industries. For example, Men's and Boys' Clothing Manufacturers are shown in three groups, as follows: manufacturers selling through their own stores, those selling to the trade, and manufacturers selling direct to the wearer. The results vary considerably depending on the channels of trade, the size of corporations, and, of course, from industry to industry.

The projected financial reporting system will be developed to take account, as far as practicable, of existing information—such as is provided by the Securities and Exchange Commission—and will reflect the needs of all Federal agencies as well as the needs of business. All important lines of manufacturing and trade will be covered and industry tabulations will be made showing all relevant data by all useful classifications. The samples will be selected to afford proper representation. Moreover, comparative tabulations covering the war years will be prepared and efforts will be made to relate the forthcoming tabulations to those provided by the Bureau of Internal Revenue (based on income tax returns) and by the specialized regulatory Commissions such as the Interstate Commerce Commission. It is probable also that a quarterly system of reports will be developed and related to the annual system. The full establishment of the financial reporting program will entail many complexities and difficulties, but the results will fulfill a long-felt need.

Accurate facts with respect to investments and operations of our industrial and distributing corporations are needed to furnish sound

and adequate data on which business men may base their decisions. Knowledge of volume of production and volume of operations of our leading industries is also needed. There are important industries in the United States that are seldom operated in excess of 50 per cent of their capacity. For the first time in the history of our country, a comprehensive, coordinated, statistical plan that covers a wide range of industries, and includes production, sales, costs and profits has been developed by the cooperative action of several operating agencies and the U. S. Bureau of the Budget. No other country has ever had an opportunity as favorable as that now afforded American business to build a sound post-war economy. The Government's statistical plan should enable owners of our risk capital to avoid the industries offering the smallest chances of success, and pay dividends to consumers by increasing competition in high profit industries.

THE STATISTICAL PROGRAM OF THE CENSUS BUREAU

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THE outstanding fact about the statistics of the Bureau of the Census today is that they do not constitute a program. They do not constitute a program because they were never designed to be one. Whether mandatory or permissive, they have developed in response to various historical forces and today represent an aggregation of items which were never conceived or planned in their totality as a program.

The Census statistics are based partly on constitutional requirement (Article I, Section 2); partly on the organic act creating the Census Bureau in 1902; partly on the several statutes governing the Bureau's activities passed since its organization; partly on the general authority granted to the Secretary of Commerce authorizing him to order surveys which he deems to be "necessary and urgent"; and temporarily, partly on the authority granted the President under the Second War Powers Act.

Our national economy, our social structure, and our Government have undergone profound changes since the Bureau of the Census, shortly after the turn of the century, was founded as a permanent agency of Government. During this period great developments have also occurred in the social sciences, in statistical techniques, and in research activities of universities, of business, and of Government. This period

has witnessed an increasing awareness of and dependence on facts, especially quantitative facts amenable to statistical treatment as a basis for policy formulation and action in both private and public spheres of life.

The profound changes which have occurred during these decades have, of course, made considerable imprint on the statistical services of the Census Bureau. Statistical series have been modified and improved from time to time, techniques have been improved, and personnel has been strengthened.

One of the most important and in the long run the most far-reaching changes which has occurred in the Census Bureau during this period, and in many other agencies as well, is the strengthening of professional leadership.

We have just emerged from the great crisis of war which drew materially upon the statistical as well as the other resources of the nation. The war found us statistically unprepared, just as it found us unprepared in many other respects. Under the pressure of war, large additions were made to the Government statistical program, including that of the Census Bureau, to help meet urgent national and international requirements. We are now faced with the important problem of statistical reconversion and it is particularly fitting at this time, therefore, to re-evaluate the statistical work of the Census Bureau, with a view to designing an integrated statistical program. This task has been undertaken by the Census Bureau's staff under the vigorous leadership of Director J. C. Capt and as a result a Census program has been planned. Some parts of this program are already under way, but much of it is now before the Congress awaiting favorable legislative authorization and appropriations.

The proposed Census program can be characterized briefly as follows. First, in recognition of current business and Government needs, it places great emphasis upon current statistical series to provide statistics for current uses, while still recognizing the importance of the benchmark censuses. Second, it proposes to achieve balance among the various census undertakings with respect to the frequency of the benchmark and current statistical collections of data—to achieve a better correlation between need and use on the one hand and collection and publication of data on the other. Third, it intends to stagger the large-scale complete Census operations so as to level off the peaks and troughs in the workload handled by the Census Bureau in the course of a decade, while improving the availability of inter-related data for correlative use. Fourth, the program places emphasis on prompt pub-

lishing of statistical reports and on careful indexing of available materials on a current basis to increase the availability of the data. Fifth, the Census program carries with it the prospect of developing a strong permanent field force which in the long run is essential for achieving and maintaining good quality in the collection of data. Sixth, it makes utilization, wherever it is feasible to do so, of modern sampling techniques to provide adequate statistics at minimum public expenditure and with the utmost timeliness. Seventh, it places emphasis on statistical research to assure continued improvement of sampling, interviewing techniques, questionnaire design for accurate response, manual and machine processing of data, and analytical techniques. Eighth, it attempts to provide a maximum of local area data as well as national data in both the current and benchmark programs. Ninth, it aims at the development of questionnaires and publications in full cooperation with respondents and consumers of data so as to hold to minimum the harassment of respondents and maximize the usefulness of the statistics. Tenth, it involves close working relationships with the Bureau of the Budget and with other Federal agencies to assure a minimum in duplication of effort and to effect coordination, integration, and articulation of Census statistics with the related statistics of other agencies.

What are the specific elements in the proposed new Census program? The substantive work of the Census Bureau falls naturally into seven parts which serve as a basis for the Bureau's divisional organization along subject lines. These subjects are: population (including the labor force and housing); agriculture; vital statistics;* manufactures (including mineral industries); business; foreign trade; and state and local governments.

The imbalance in the present frequency of the basic complete Census operations is evident by merely mentioning the fact that the law now provides for a quinquennial census of agriculture but only a decennial census of population and the labor force with no continuing provisions for housing; for a biennial census of manufactures but only a decennial census of business (wholesale, retail, and the service trades and contract construction), of mineral industries and of local governments. Careful study of the uses of these basic benchmark data in relation to their periodicity and in light of the proposed current programs described below has led the Census Bureau staff to the conclusion, concurred in by our business, government, and research collaborators, that a quinquennial complete census pattern in each of these basic

* Subsequent to the writing of this paper, the vital statistics function of the Bureau of the Census was transferred to the United States Public Health Service.

fields would produce a better-balanced and more useful statistical product.

In addition to achieving a better balance among these complete census operations it is planned to stagger the censuses so as to spread the operating load more evenly during the decade. This could easily be accomplished without interfering with the use of inter-related data by conducting the population (including the labor force and housing) and agriculture censuses simultaneously in years ending in 0 and 5; the censuses of manufactures, mineral industries, and business in the years ending in 7 and 2; and the census of governments in the years ending in 6 and 1.

Under the proposed program the "complete census" undertakings would be designed primarily to fulfill the following functions:

1. Provide information for the small areas of the nation, that is, the counties, smaller cities, and, as necessary, even the minor civil divisions, census tracts, city wards, and city blocks;

2. Provide detailed tabulations in many variables to disclose fundamental inter-relationships;

3. Provide historical benchmarks for measuring institutional and structural changes and other phenomena too complex to obtain on a current basis.

4. Serve as the benchmark for some types of sampling and subsampling design, and for adjustment of some types of current series.

Even greater changes of program are proposed in the field of current statistics. In the field of population, labor force, and housing, it is proposed to supplement the basic benchmark information to be provided by the quinquennial censuses by three types of current general reports. First, it is planned to continue the present Monthly Report on the Labor Force, which provides current information on the size and composition of the labor force—the employed and the unemployed—and of persons not in the labor force. Second, it is planned to supplement this operation with a quarterly survey of the same type which would permit similar estimates for the larger metropolitan and industrial areas of the nation. Third, it is planned to conduct an annual sample census of population which would provide information for the states, large cities and metropolitan areas, and urban and rural sections of the country. Each of these operations would make possible the simultaneous collection of desired information in the fields of population, the labor force, and housing. Questions and respondents will be rotated so that no great burden is placed on any given set of respondents.

Also proposed as a special current survey in the field of population

is an annual income survey to be conducted in conjunction with the sample census of population. This would provide basic information on family and individual income by size groupings and provide valuable data, for marketing and other uses. Finally, in the field of general population data it is planned to institute a sound program of marriage and divorce statistics* to provide data on family formation and disorganization.

In the field of agriculture, the great bulk of current statistics is of course made available by the Department of Agriculture. The approval of the sample census of population, however, affords a cheap and efficient vehicle for an annual sample census of agriculture which could conceivably be used not only to improve collections of current information but also to remove much of the pressure for information which is now placed on the quinquennial census operation.

In the field of statistics relating to manufactures, important changes are also contemplated. The present program of biennial statistics for manufactures does not provide most of industry and business with statistics of sufficient timeliness for current use, yet it is an expensive and time-consuming undertaking which provides some types of data that are just not needed as often as biennially. The pre-war current statistical program for manufactures, with the exception of the annual lumber survey, the farm implement survey and a few monthly surveys on textiles and apparel, typically consisted of relatively inconsequential current reports, the result of special pressure rather than any over-all evaluation of need.

It is proposed to supplement the planned quinquennial census of manufactures with a strong current program of manufactures statistics. Surveys are to be conducted on a monthly, quarterly, or annual basis, in accordance with the dynamic character of the industries involved, and with the need for, and availability from other sources of, current information. In addition, it is planned to prepare a yearbook for manufactures which, on an annual basis, will provide a picture of manufacturing in the United States in total and by regions and industries.

The current program of mineral statistics, is of course, provided by the U. S. Bureau of Mines. The Census plan, however, in addition to a quinquennial census of mineral industries, envisages a better integration and articulation of statistics of manufactures and those relating to the mineral industries through improved cooperation of the two bu-

* Subsequent to the writing of this paper the collection of marriage and divorce statistics was transferred to the United States Public Health Service.

reaus. Particularly important in this respect is the development of information on consumption of materials.

At present, Census statistics relating to business (wholesale, retail, and service trades and contract construction) are perhaps the furthest from satisfying current needs. Perhaps nowhere among the various Census statistics is there a greater gap between consumer demand for data, and statutory and appropriation provision to meet the demand. For retail, wholesale, and the service trades two basic innovations are proposed. First, it is planned to conduct a monthly survey of sales for retail trade and receipts for the service trades. A series of individual trade and commodity reports in the wholesale field will provide information on this important segment of distribution and carry forward certain of the related studies in the manufacturing area. Second, it is planned to conduct an annual survey of business (wholesale, retail, service trades, and contract construction) to carry forward the complete census operating information through intercensal years. Each of these projects will provide data not only for the country as a whole and for its broad regions, but for most of the states and the large cities.

In recognition of the increased importance of state and local governments as an element in the national economy as well as a political and social force, it is proposed to survey quinquennially the approximately 155,000 state and local governmental units which comprise the United States, and have a total payroll of over 3,000,000 persons and an approximate total annual expenditure of over $13,000,000,000. In addition, it is proposed to strengthen the current collections so as to provide data for all cities which have 25,000 or more inhabitants and on a sample basis the counties and smaller units of government, both with respect to financial and non-financial activities.

This, in brief, is a picture of the highlights in the proposed Census program. What purposes will it serve? The first and perhaps the most important purpose is that of providing useful information to the business community. In a free enterprise economy such as ours, it is in the interest of individual enterprise as well as in the public interest that business operate as efficiently as possible. There is no doubt but that a sound factual basis for formation of business policy and for dealing with management, production, and marketing and distribution problems would contribute materially to increased business efficiency. In fact it is inconceivable in the complex and interdependent economic system which we have developed that business and industry can make intelligent decisions in the absence of facts relating to its own operations and to operations which come before and after it in the long process of

converting raw materials into a finished product for consumer use.

The proposed Census program, particularly as supplemented by the statistics available from other Federal agencies and various private sources, would supply the business community with basic benchmark data and certain current information on the extractive industries: mining, forestry and agriculture, on manufacturing and fabricating, and on the various channels of distribution. It would provide basic information on the availability and character of the labor supply. It would also present a comprehensive and current picture of consumer, as well as industrial, markets; would indicate the potential purchasing power and other characteristics of consumer markets; and would, in addition, indicate the extent of need or the degree of saturation of markets for some of the more important consumer durables including housing and housing facilities.

Thus, although the ultimate in the form of a statistical program of maximum usefulness to business will not have been achieved, the proposed Census program would go far in the direction of providing the business community with basic metering points in the chain of supply that will enable it more intelligently and efficiently to conduct its daily operations.

A second and quite important consumer of the statistics of the proposed Census program is the Government itself. With the increasing complexity of our society, Government functions have continuously increased and the sphere of Government and business relations has been greatly expanded. It is of vital importance that the Government have a sound factual basis for policy formulation and legislative and administrative decision.

Third, and by no means unimportant, is the long list of consumers of Census information represented by educational and research institutions, social organizations, labor organizations, religious institutions, *et cetera*, many of which are dependent upon sound Census facts to help them make their contribution to our society.

Congressional action during the past few months with respect to this proposed program has been most encouraging and provides a basis for reasonable expectation of its fulfillment. However, a considerable part of the basic statutory authorization and appropriations remain yet to be obtained. Moreover, considerable hard work remains for the Census staff which is faced with the enormous task of developing the details of this program. This we all realize can be achieved efficiently and successfully only by close collaboration with the many respondents and consumers of Census statistics.

DEVELOPMENTS IN LABOR MARKET AND PRICE STATISTICS IN 1945 AND 1946

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I HAVE been asked to report on current and prospective developments in the field of labor market and price statistics. In view of the time limitations I shall confine myself to what I hope may be a convenient summary.

PRICES

In connection with prices, it should be noted that on the whole, over the past year, the volume of our work has decreased slightly. This has affected especially the number of cities covered and the frequency with which we collect changes in consumer prices. In this connection, however, it is important to note that a number of State Labor Departments are interesting themselves in the possibility of developing consumer price indexes in their States for cities not covered by the Bureau of Labor Statistics. Such figures are already available for a few States. We are cooperating with others and hope that, as a consequence, information on price changes in local areas will become more abundant.

While our current work in the compilation of indexes of consumer price changes is less extensive than it has been for the last several years, there have been important developments in the price field. With funds which have been used to check the extent of agreement between prices reported by store managers to our field agents and prices that consumers say they paid for goods, we have secured valuable by-product information with reference to the distribution of urban family income and the distribution of family expenditures. The sample with which we have been working has been small, but drawn up in such a way as to be representative of urban families generally. Data for 1944 and 1945 are becoming available.

We are about to publish indexes showing the influence of price differentials and climate on the cost of living among the 34 cities regularly covered in our consumers' price index. These indexes will replace the ones discontinued in 1943. Like the earlier series, the series will show that differences in expenditure and living habits among communities are far more a reflection of differences in prevailing income than of differences in prices or of strictly climatic factors. The commodities selected for inter-city comparison have been those with respect to which the greatest uniformity of specification exists. As part of this study in

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measuring inter-city differences, we have developed techniques which can be applied to measure differences at any given time between communities which we regularly cover and other communities.

Akin to this project is another which has involved the development of a standard budget. The measures of inter-city differences just described will be expressed as index numbers. There is also a demand for an absolute figure for the cost of a worker's budget. Funds for this purpose were appropriated this year and a committee of experts has been aiding the Bureau in developing the specifications for a standard budget for a working man's family. The main problem in connection with the development of such a budget is the judgment factor inherent in the definitions of adequacy. Objective standards exist for some groups of commodities, but for other groups one must rely heavily upon judgment and accepted practice. It is too early to forecast the results of this study, but they should be available in the near future.

The last development in the field of prices that I wish to mention is the development of export and import price indexes. These are called for in connection with the administration of the Bretton Woods Agreement. It cannot be assumed that the general wholesale price index adequately measures movements of prices as they affect foreign trade. The new indexes should do so. As foreign trade expands and studies of price relationships with particular countries become more important, it is probable that there will be need for more information that can be currently provided.

EMPLOYMENT STATISTICS

In the field of employment and pay-roll statistics, the most important development during the past year has been the project for State employment and pay-roll statistics. Figures for the movement of employment in the leading manufacturing industries since 1939 are, or shortly will be, available for each of the 48 states. These figures are being published as absolutes rather than indexes so that the over-all importance of trends of employment may be quickly visualized. Within the year, figures will be available as well for the leading categories of nonmanufacturing employment in each of the States. One important by-product of this project is that it will make it possible for us to develop far more reliable national figures for employment in construction and in industries where small establishments contribute importantly to the total volume of employment.

The most important current lack in employment information is that which relates to the local labor market. The U. S. Employment Service

has vastly improved its facilities for appraising local labor market conditions. The objective that the Department of Labor is trying to attain is one in which employment and other related information collected by the Bureau of Labor Statistics will be utilized by the local employment offices for background information. The interpretation of these local data and the projection of important local developments in the labor market depends, however, upon an intimate day-to-day contact with employers, trade unions, banks, Chambers of Commerce, and other local groups. It is this type of contact which the local offices of the Employment Service are in a position to make. Currently, the Department of Labor is in a better position to develop this sense of local developments than it is to supply the Employment Service and other local interests with the necessary statistical background. We hope that a program for the development of local area employment and pay-roll information similar to the State program may be developed in the near future. The basic practical problem that must be solved is, first, that of developing adequate benchmark information with reference to individual areas from the Unemployment Compensation and Old-Age and Survivors Insurance reports. When such benchmarks have been established, employment estimates may be kept up-to-date through the selection of a current reporting sample. Our present sample would not have to be greatly enlarged in order to make sure that it was adapted to local employment reporting.

OCCUPATIONAL OUTLOOK

Within the field of labor-market information, there has been an important change of emphasis in the work which we are doing in connection with occupational outlook. It will be reflected in both the work of the Employment Service and of the Bureau of Labor Statistics. During the war, there was comparatively little need for information to be used for vocational guidance or employment counseling. The main problem was to estimate labor requirements for vital munitions industries and to determine how people could be channelled into those industries. Thus, the work which the Bureau of Labor Statistics started in 1939 on occupational outlook was largely transformed into a war-time program of estimating labor requirements. Currently, there is a greater demand for information on employment and occupational outlook than we have ever experienced in the past, and our resources, supplemented by funds received from the Veterans' Administration, are being devoted to long-range occupational outlook analysis and to a current and long-range analysis of employment opportunities in leading industries.

Similarly, the efforts of the U. S. Employment Service are being directed increasingly to the adaptation and use of these and other materials for actual counselling of individuals.

LABOR PRODUCTIVITY

The Bureau has just received supplemental funds to expand its work in the field of the productivity of labor. During the war, we have been handicapped in this field by the absence of a Census of Manufactures as well as by the technical impossibility of developing significant indexes of productivity in many industries in the face of a complete change in the types of product manufactured in many establishments. After an extensive exploration of all of the data available in this field, we could find only 24 civilian-type manufacturing industries for which current information on man-hours and production were sufficiently comparable to make it possible to trace changes in output per man-hour through the war period. In addition, we have indexes for mining, transportation, and certain other nonmanufacturing groups as well as indexes for shipbuilding and aircraft.

Information on labor productivity will be desperately needed during the next few years when we anticipate an extraordinarily rapid increase in output per man-hour in most industries. We did experience a similar rapid increase in productivity in the years immediately following the First World War. In the event of such increases, discussions about productivity of labor will be in the center of many wage negotiations.

Faced with the certain need for information and our knowledge of the inadequacy of existing data, we are bending every effort to secure more adequate and reliable data. Immediately we are planning a series of exploratory studies to develop indexes for industries such as iron and steel (for which no index could be currently compiled), automobiles, and textiles. For other industries, such as electrical equipment, washing machines, and refrigerators, we believe that it is possible to develop a new type of measure in this field. We believe that it will be possible to secure reliable information with reference to labor requirements for specific products and to measure changes in labor requirements for such products from time to time. We think that this will enable us to secure better measures of productivity in industries manufacturing a multiplicity of products.

LABOR REQUIREMENTS IN CONSTRUCTION

Related to this study is another on labor requirements in the construction industry. Almost all information now available with respect

to the amount of labor required in connection with any given public works or other construction program dates back to the 30's. We believe that significant changes have developed since that time and that reliable estimates as to the amount of employment that will result from any given construction program require new information. Such a project is just getting under way in the Bureau of Labor Statistics. It will presumably not be completed for a year and a half or perhaps two years.

STATISTICS ON WAGES

The most significant development in the Bureau of Labor Statistics with respect to wage information occurred several years ago. At that time, we began to compile for the War Labor Board local information on occupational wage rates and earnings in most leading industries. From these figures, used chiefly to determine existing rates and earnings and their spread, we have also developed an index of urban wage rates which measures reasonably accurately changes in straight-time earnings without regard to shifting occupational composition. Unfortunately, these series only extend back to April 1943 and indexes are only available for the broad groups of manufacturing and nonmanufacturing industries. This index enables us to measure with some degree of reliability the spread that has developed between wage-rate changes based on general "across-the-board" increases, and increases brought about by increased incentive earnings, merit increases, up-grading, and other factors that are the result of internal administrative arrangements within the establishment.

It is significant that the wage report for October which has just been published shows that there has been a reversal of wartime developments. During the war, administrative arrangements worked out by management with individual workers or small groups of workers tended to raise average hourly earnings more rapidly than basic wage rates were increased. It has been pointed out frequently by labor that these arrangements are reversible and will probably be reversed in any but a tight labor market. The Bureau's figures, which covered the period from April to October 1945, show that within that 6-month period as a whole, there had not been any important net down-grading of labor. I wish to emphasize the word "net" in this connection because we found some instances of up-grading and others of down-grading. In other words, down-grading is going on, but during the period ending in October 1945, it has not yet significantly affected our index of wage rate. On the other hand, we did find that incentive earnings had declined, as is to be expected in a period of declining production such as we still

had in October. It is significant, therefore, that it was only because of the general wage-rate increases that were granted after V-J Day that our wage index moved up at all.

While I am talking about straight-time hourly earnings, I should like to advise you of the danger of attempting to estimate straight-time hourly earnings in any particular industry from the figures which the Bureau of Labor Statistics publishes on gross average hourly earnings. The Bureau did develop a formula to eliminate the effect of overtime—but not of night-shift differentials and a variety of other factors—for the over-all average for manufacturing. At best, it is a crude measure which we developed as a general guide during a period when the increasing length of the workweek was influencing the movement of the series of gross average hourly earnings. This formula has been widely used, in the absence of any other available data, to estimate changes in straight-time hourly earnings in individual industries from January 1941 to date. It is not possible to tell without analyzing the situation in each industry in detail whether such estimates are good or bad. We ourselves feel that they are probably a useful administrative tool to establish a presumption as to whether earnings have increased substantially more than 33 per cent or substantially less. We do not believe that the estimates thus arrived at are accurate enough to be used in the final stages of bargaining when a few cents may make a great deal of difference. The only way that we know of to measure changes in straight-time hourly earnings is to build such measures from the records of individual establishments or groups of establishments.

WORK EXPERIENCE

The last study that I wish to discuss is one initiated about a year ago to obtain work experience information directly from individual workers. Virtually all the labor-market information which exists is derived from employer reports. The employer can tell you with great accuracy how many people he employs and what he pays them, but averages derived from such reports will not give an account of the work experience of an average individual. During the war, for example, we know that manufacturing employment expanded from 8,000,000 to 12,000,000, and that the average weekly earnings of the 12,000,000 were substantially higher than the average of the 8,000,000 had formerly been. We know very little indeed about what happened to the earnings of the 8,000,000 who were originally engaged in manufacturing. Some, of course, died, retired, entered the armed forces, and in

other ways disappeared from the labor force. We simply do not know what the individual experience of those who remained in factory employment was. All we can do is to guess that under the labor-market conditions which prevailed during the war, the average situation of the group that had been employed in 1939 improved somewhat more than was indicated by our over-all current averages. As a matter of fact, it was probably only because opportunities for individual advancement existed that our wage stabilization policy could be carried out as vigorously as it was.

We do know that in the postwar period this situation will be reversed. We are already experiencing vigorous complaints as to the loss of earning power that results when an individual in a more limited labor market must accept a lower-paid type of employment than that which he formerly had. This type of down-grading is not reflected in our averages, but it is one of the significant social facts of the period in which we are living.

The Bureau's studies in this field are not designed to cover a fully representative cross-section of the workers in the United States. We have attempted rather to draw representative samples from different typical situations that will illustrate the problem rather than measure it statistically. The results of these studies will become available gradually. Preliminary reports which have been made to me, but have not yet been published, indicate how severe a loss many of the displaced groups have faced. These statistical case studies will be indispensable tools for those who attempt to interpret the current social scene.

POST-WAR STATISTICAL PLANNING IN THE DEPARTMENT OF THE INTERIOR

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The expansion in Interior's activities occasioned by the war program required new statistics and statistical uses, some of which have wide support for continuation during peacetime, when regulation will be absent.

Interior has 18 bureaus, or their equivalent, exclusive of the Department's administrative organization, representing a wide range of functions. Most of the bureaus deal primarily with the utilization and protection of natural resources. The war gave heavy additional responsi-

* Now with the Consolidated Coal Co. of Pittsburgh.

bilities to some of the agencies; activities extended from the advisory to the regulatory, and in some cases entered the field of Government operation. Statistics therefore gained a prominent place in the work of the organizations.

Most of Interior's statistical activity furnishes informative data for general use centers in the Bureau of Mines and Fish and Wildlife Service. These two agencies have provided established series of information for many years. During the war the Bureau of Mines cooperated with the War Production Board and other war organizations by furnishing basic data on the production, processing, and marketing of numerous minerals. It worked closely with the Petroleum Administration for War which, though not part of Interior, was closely allied to it and provided the main statistical and technological service for the Solid Fuels Administration for War.

The greatest utilization of statistics during the war was in connection with the anthracite and bituminous coal industries. All phases of industrial operation were entered into at one time or another, including operation of the mines. Current statistics were obtained and compiled on production, manpower, costs, prices, market distribution, and stocks. Their analysis provided the basis for policy and the framework for regulation. All major operations were guided by statistical controls.

It is generally conceded that without adequate statistics the wartime coal program would have failed miserably. Information had to be available for the orderly planning of supplies and requirements, and for disposing of problems continually appearing on mining costs, prices, manpower, and other phases. An interesting development, however, is that the coal industries contend that the essentials of the wartime statistics must be continued during peacetime although no regulation is in view.

There are several reasons for this contention. The bituminous coal industry has been active in the development of statistics since 1937 when the Minimum Price Act was made effective. Termination of that Act in 1943 did not retard the growing activity which had taken on a new impetus because of war conditions. The anthracite industry used statistics extensively prior to the war, but found useful improvements in the information developed under wartime regulations. Statistics have become ingrained in industrial operations. Both industries claim they will be at a disadvantage in the future if they do not have general information supplied by the Government which can be used for guidance in their planning and determinations, and comments from representatives of other mineral industries indicate a similar viewpoint.

The Fish and Wildlife Service, responsible for the statistics on the fishing industries, had additional assignments in the furnishing of information during the war. It processed information for the Office of the Coordinator of Fisheries which required data on many phases not previously covered. During and since the war, the Service had found that statistics are being used much more widely in the industries and elsewhere. Today, there are an increasing number of requests, particularly for current market reports and for analyses of market outlooks.

Other Interior agencies, such as Reclamation, Power, and the Land Office, collect principally administrative data with respect to their own operations, but their statistical interests extend beyond this activity. They have found an increasing use for general statistical information obtained elsewhere which is useful in outlining projects, making decisions, and evaluating operations. During and since the war, there have been important undertakings which required broad statistical studies in arriving at determinations. These agencies are building staffs which will specialize in economic and statistical analysis.

POST-WAR STATISTICS

Several points are given emphasis in Interior's post-war planning in view of the expanding interest in statistics, starting with the war period. They take account of the greater familiarity with statistics generally, and the growing importance of statistics in policies and operations, both inside and outside the Government. They reflect the improvements in information service resulting from the application of statistics more directly to industrial operations and consumer requirements.

First, it is believed that additional stress should be given to analysis and interpretation. Before the war, meagre funds too often limited the statistical product to a bare set of tables. The value of the data collected was never fully realized by the Government, industry or the public. During the war, analysis and interpretation became a necessity in many cases, and the value of the additional information developed was quickly recognized. It is planned to extend the analytical and interpretative work to all major statistical fields. Funds have been authorized which permit a modest start in that direction.

Second, certain modifications in the system of reports have been found to be necessary. At the start of the war, little or no information existed on certain fields, and it was essential to have more frequent information on others. There was inadequate information available on productivity, employment, consumption, and marketing aspects of particular industries. Data on the development and utilization of

natural resources in foreign lands was sketchy and obtained from secondary sources. Improvements are being made with reference to all of these phases. While it is not contemplated to have the same detail as needed for war regulation, the modifications in the reports will make the statistical systems better balanced and more complete.

Third, there should be a closer association with industries that report the data. Much of the information collected by the Bureau of Mines and the Fish and Wildlife Service is supplied by industries. Frequently, these industries have or can designate committees to assist on the statistical work. These committees where established have been helpful in setting up questionnaires to conform with industry records, in obtaining more complete returns, and in aiding the work on interpretation. An association of this kind creates good will and encourages the industries to take a more active part in the use of statistics. It is particularly desirable since most of the statistics are obtained on a voluntary basis.

Besides immediate considerations, Interior's statistical planning takes account of the obvious necessity for future expansion in statistical activities. A larger amount of information will probably be required on natural resources in each succeeding year. There is likely to be greater concern over whether supplies will be adequate to satisfy the requirements of our economy and national security.

Minerals present a complex set of problems. Their continual depletion first means increasing costs as the better grades disappear and extraction becomes more difficult, and finally it means exhaustion of the resources that are not replaceable. Both the higher costs and the tendency towards exhaustion shift the dependence for supplies upon foreign sources or upon substitutes. If the shift is not well planned, our industrial activity is adversely affected by shortages and unfavorable cost differentials. The changes in the supply patterns are gradual and are to be viewed over a long period. Their measurements involve intricate techniques which touch on all phases of the production, marketing, and consumption of minerals. Moreover, they must be made with reference to the requirements of the general industrial system.

The heavy drain on our mineral resources during the years through the war period has depleted the larger part of the reserves of certain basic minerals and cut heavily into others. Serious problems on supply will appear in the not too distant future. A large amount of information will be required to furnish a basis for the orderly planning necessary to assure that adequate supplies will be provided.

The present emphasis on analytical and interpretative statistical

activity will do much to develop methods and applications to be employed in determining the long time supply requirements. Limited studies already undertaken have demonstrated the feasibility of estimating mineral needs for some years ahead. The statistical work that will be required in the future, however, will be far more extensive than the work provided for today. Further, much more statistical preparation should now be under way as a foundation for the subsequent expansion. Proposals in this regard have not been successful. Later, the need for more information will be urgent and requests will not be met unless more provision is currently made for statistics.

The Fish and Wildlife Service likewise finds that it will have to increase statistical activities in consideration of future developments. More information is needed on certain fish resources, particularly as to the effect of catch on stocks. Expansion is likely in the information on fishery products, industry investment, and income. Additional information of this character is necessary if adequate supplies are to be maintained while resources are efficiently utilized.

It may appear that Interior's statistical planning is being undertaken with a great deal of optimism. The termination of war agencies has withdrawn support from the war statistical programs. Appropriations are now being scanned to seek possible decreases. On the other hand, there are some favorable conditions pointing towards better statistics. Information on natural resources was skimpy before the war, and this deficiency needed urgent remedy once the war began. It is generally agreed that we cannot return to the pre-war status of ignorance. Statistics now have a broader use and have gained considerably in prestige. These conditions will not at once occasion strong support for a more liberal statistical program, but it is likely that general opinion eventually will insist that adequate statistics be provided.

SOME ASPECTS OF THE STATISTICS PROGRAM IN THE DEPARTMENT OF AGRICULTURE

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THREE major parts of the statistical program of the United States Department of Agriculture in the immediate future should be mentioned: providing statistics which will permit adequate differentiation among the variety of situations and problems included in American agriculture; filling in the gaps that still exist or that may develop in

* Now with the Food and Agriculture Organization of the United Nations.

the statistics of agriculture and food; and improvement of the techniques of collecting and analyzing statistical data.

More adequate differentiation of the aggregates which are currently available are needed in the basic statistics on farms and farm population. Within the totals encompassed by these concepts there is a considerable gradation in the degree of dependence on agricultural production. It is anticipated that public programs dealing with agriculture will be differentiated increasingly among commercial farmers, subsistence farmers, part-time farmers, and open-country residents who live on tracts of land sufficiently large to qualify as farms, and thus they will deal separately with those elements in agriculture with relatively greater or less flexibility. Moreover, the support of the family farm as an objective of agricultural policy will require a clearer statistical description of the family farm than is now available either in basic statistics, such as those provided by the Census, or in the current statistics provided by the Department of Agriculture.

QUARTERLY SURVEY OF AGRICULTURE

The development of area sampling and of enumerative survey techniques has opened the way to an improvement in statistics relating to agriculture that are being collected currently. It has also opened up the possibility of securing some types of data which have not been available previously. These techniques are especially useful in providing data that permit differentiation within the aggregates currently in use. Through quarterly interviews of a panel of farmers, estimates of the distribution of incomes of farms and of farm families in 1945 are becoming available. It is planned to continue and expand this work in 1946. Such data are necessary to an interpretation of developments in agriculture and to provide a basis for evaluating changes in aggregate receipts from marketings, or other measures of aggregate incomes. In addition, similar data are being developed to show the distribution of farm expenditures in relation to farm income, type of farm, or farm size. Information is also being collected on individual farm-family expenditures and savings in two major farming areas, and additional work in these directions is planned.

By spreading the collection of data over four interviews—and in some cases five—much of the error due to seasonal fluctuations and memory bias is eliminated, and it becomes possible to deal with the farm enterprise as a whole, without imposing undue burdens on the respondents. It is believed that the data resulting from this activity—the Quarterly Survey of Agriculture—will provide information on the

effects of changing prices and incomes on farm families, and will also provide information on the purchasing power, liquid assets, buying habits, and levels of living of farm families.

At present, this quarterly survey is small; it covers a sample of 101 counties. The sample was so designed that it can be readily expanded to meet special needs. This effort may well be the forerunner of an annual sample enumeration to provide agricultural data.

OTHER CURRENT STATISTICS

The administration of the wartime food programs necessitated the collection of new statistics, as well as more adequate coverage in some fields. In some cases it provided a base for a continuing program of current statistics. For example, the emphasis on oil crops, especially soybeans, called for more adequate statistics on soybean production than had previously been available. These were developed and are to be continued. The large-scale migration from farms during the war made it necessary to provide more adequate data on farm population and farm-population shifts. The new information to be supplied will provide not only information on age and sex of migrants, but will include also the seasonal flow of population to and from farms as well as the relation of migration to farm income and other characteristics of farms.

During 1945 the Congress authorized a program for expansion of data relating to agricultural wages and wage rates, and this program is to be continued. It will provide current estimates of wage rates and earnings in agriculture with regard to season, type of operation, method of payment, perquisites, tenure of employment, the characteristics of the worker, and the characteristics of the farm on which he is employed. Through these data and the information on agricultural employment, which are a byproduct, it is planned to develop, for agricultural employment, current data similar to those currently available for nonagricultural workers.

The new emphasis on food and nutrition necessitates the collection and analysis of more adequate data on food as distinct from agricultural products. In the case of livestock slaughter and meat production, for example, the information available before the war covered only the plants that had Federal meat inspection. During the war data were needed from other slaughterers. This resulted in the formulation of a statistical base on which a sample reporting plan for that segment of the industry is being developed. Likewise, the need during the war for statistics of manufactured dairy products provided a base for more

complete current reports on the production of butter, cheese, ice cream, dried and evaporated milk, etc. The statistics to be developed in this field will provide, more completely and more frequently than was previously possible, data needed by the Government, by farmers, and by the dairy industry. At the same time plans have been made to provide comprehensive reporting on production and disposition of fluid milk in the important Northeastern dairy area.

Food consumption is a relatively new field for statistical reporting. Disappearance figures or average per-capita consumption figures cannot substitute for direct data on food consumption and differentials in food consumption, such as those which were provided in the Consumers Purchases Survey. The studies of family expenditures planned in the Departments of Agriculture and Labor will provide, on a current basis, more nearly complete information on differentials in food consumption than is now available fron any source, and will provide a current basis for estimates of food consumption by income groups. Such information is essential if agricultural production and nutrition are to be more closely integrated. It will also meet some of the expressed needs of the food trades.

Prices and price statistics are expected to loom large in the agricultural programs of the future, and plans have been made to meet the variety of needs that are developing in this field. Market news reports are being expanded to cover the interior markets which have become increasingly important in the marketing of livestock and poultry and poultry products. Statistics on average prices received by farmers are to be made more adequate by increased coverage and by more clear-cut differentiation of the components of the prices reported.

Plans to fill one of the major gaps in agricultural statistics—that relating to the distribution of income, expenditures, and savings—have been outlined above. This work is progressing on a relatively small scale. Should large-scale surveys become possible at some future time, this experience would greatly increase their efficiency.

Some of the work outlined, as well as the proposed improvement in statistics on farm construction, assumes a continuation of the close cooperative working relationships among Federal agencies that prevailed in the planning of the Federal Program for Economic Statistics which was first developed late in 1944.

RESEARCH IN METHODS

Continued research in methodology is an essential part of the Department's statistics program. In cooperation with the Bureau of the

Census and the Statistical Laboratories at Ames, Iowa, and Raleigh, North Carolina, the research on problems of area sampling and of the relative merits of area and other methods of sampling is to be intensified.

Much of the current reporting on crop and livestock production and prospects is dependent on mailed questionnaires. Research is to be resumed on the question of bias in mailed questionnaires, and on means of eliminating the effects of such bias. Early in January of this year a mailed questionnaire was sent to a list of 20,000 farmers who had been interviewed three times on related subjects during 1945. The information available about all the persons on the mailing list is to be used in expanding the data, and in testing the effects of various methods of expansion that might have been used to arrive at aggregates and changes, if only the information about those who responded to the mailed questionnaire had been available.

Currently there is also a threefold project to secure data on land ownership, mortgage indebtedness, and wage rates through the use of mailed questionnaires. The basic mailing list represents an unbiased sample of all farmers and landlords. Some pertinent background information for each farm is included in the list. Arrangements have been made to test the selectivity of the respondents from each mailing, including a follow-up mailing, and to reduce the effects of this selectivity in the final estimates. As part of the project there is to be some follow-up enumeration of nonrespondents which will provide, among other things, an opportunity of securing direct information on the reasons for nonresponse.

Another proposed research project includes a careful study of the enumerator-respondent situation. With increasing reliance on enumerative surveys there is urgent need for study of the techniques used to obtain information from respondents and of means for improving these techniques. Improved sampling plans may have relatively little effect on the accuracy of results if there is no assurance that enumerators actually get the information called for. Recent experience in the collection of current data on employment and unemployment has shown dramatically how a change in emphasis in instructions can affect results. The Quarterly Survey of Agriculture provides a unique opportunity in this respect, for it imposes the severe test of four interviews with each respondent in the course of one year and offers opportunities for checking responses on a scale usually not available in single-time surveys.

PROBLEMS OF MULTIPLE-PUNCHING WITH HOLLERITH MACHINES

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In recent years, it has become increasingly popular—particularly in research work—to resort to multiple-punching as the solution to specific problems encountered in the utilization of Hollerith (IBM) techniques. Occasionally, the potentialities of multiple-punching are overlooked where they would afford relief; much more frequently, however, the disadvantages, and the complications its application creates, are not realized by the investigator devising his code. It is the purpose of this article to summarize and illustrate all the essential "pros and cons" involved in multiple-punching. The discussion includes codes which make provision for multiple-punching either consistently or under particular conditions, and their effect upon IBM machine procedures. It is assumed that the reader is already familiar with Hollerith methods.

DEFINITION OF MULTIPLE-PUNCHING

THE term "multiple-punching" is employed here to signifiy the punching of more than one hole in the same column of a Hollerith card (excluding the special case of alphabetic-punching, which always consists of a numeric plus a zone punch in the same column).

REASONS FOR MULTIPLE-PUNCHING*

A. *To record the simultaneous applicability of several items of the same type—henceforth referred to as a TYPE I multiple-punch code:*

a) For example: Let column 10 contain the code for interim treatment received by a patient between two visits to the hospital where his case is being studied. Let the code read:

Interim treatment: 0—No information
1—None
2—Surgery
3—Radiation
4—Other form

If the patient received both interim surgery and radiation, both "2" and "3" must be punched.

(Note that it is advisable to make special provision in all codes for "no information," i.e. for every contingency, rather than leaving blanks.)

b) *Avoidance of multiple-punching in such cases:* In such a case, with a

* Throughout this article, "X" has been used to signify a punch in the "11" position, and "Y" one in the "12" position.

limited number of possibilities, all possible combinations can be allowed for in the code, thus obviating multiple-punching. For example:

Interim treatment: 0—No information
1—None
2—Surgery only
3—Radiation only
4—Other form only
5—Surgery and Radiation only
6—Surgery and other form only
7—Radiation and other form only
8—Surgery, Radiation and other form.

If the number of discrete items is greater than the five in the first illustration, two or more card columns are required to provide for all possible combinations; but multiple-punching can—if desired—always be avoided in such case.

B. *Optimum card column utilization by assigning different parts of the column to several independent variables—henceforth referred to as a TYPE II multiple-punch code.*

a) For example, assume that the code for:

1) Economic class requires only four punches;
2) Sex requires only two punches;
3) Education requires only six punches.

One card column can accommodate all three items, thus:

1) Economic class: Y—Unknown
X—Income below $2500 per annum
0—Income $2500 or over, but less than $5000
1—Income $5000 or above.
2) Sex: 2—Male
3—Female
3) Education: 4—Unknown
5—Grammar school or less
6—Some high school
7—High school graduate
8—Some college
9—College graduate.

b) *Avoidance of multiple-punching in such cases:* The special problems raised by multiple-punching of this nature are easily circumvented by assigning three separate columns to the three items. However, the above procedure may be necessitated by the desire to avoid exceeding the 80-column capacity of one card.

C. *Combination punches to increase the capacity of the number of items per column—henceforth referred to as a TYPE III multiple-punch code.*

a) *Predetermined number of punches:* Normally, the different items in a column are limited to twelve in number—i.e. the number of different individual punches possible from "*Y*" through 9. If two columns are used, (12^2), or 144, different permutations of punches are possible. However, if only one column is available, 66 different combinations are possible by always punching two holes in that column. (It should be realized that, whereas in the case of two columns, a distinction can be made between, say, 12 and 21, this is not feasible when both punches appear in the same column, nor can any one digit repeat, i.e. 22, for instance, is not available. This fact should be borne in mind when devising a code of this type, and accounts for only 66 possibilities, instead of the 144 yielded by the use of two columns.) If the code provides for six punches per column, its capacity is increased to 924 distinct items per column. With more than six punches per column the number of possibilities decreases again. The general formula is:

$$C_r^n = \frac{n!}{(n-r)!\,r!}$$

where n is the number of punch positions in the column (i.e. 12), and r is the number of punches used. For IBM cards, this simplifies to

$$C_r^{12} = \frac{12!}{(12-r)!\,r!}$$

For instance, let column 21 contain "occupation." Let us assume that the code consists of a maximum of 66 items. Two punches will therefore suffice, and the code might approximate the following:

Occupation:	YX—Doctor of Medicine	X5—Clerk
	Y0—Dentist	.
	Y1—Druggist	.
	Y2—College or Univ. faculty	X9—Other clerical, etc.
	Y3—School teacher	
	Y4—Lawyer	01—Storekeeper
	Y5—Clergyman	02—Dealer
	Y6—Nurse	03—Barber, beautician
	Y7—	.
	Y8—	.
	Y9—Other professional	09—Other service and retail, etc.
	X0—Business Executive, etc.	12—Skilled labor
	X1—Banker, Broker	13—Semi-skilled labor
	X2—Salesman	14—Unskilled labor
	X3—Accountant, Bookkeeper	15—Chauffeur, taxi or truck driver
	X4—Stenographer	

16—Miner	46—School child
17—Fireman, policeman, mailman	47—Student
18—Regular member of armed forces	49—
19—	56—
23—Farmer	59—
29—	67—Retired
	68—Unemployed
34—Housewife	69—No occupation
35—Housekeeper	
36—Unemployed Widow	78—
	79—Other occupation
39—	89—Occupation not stated
45—Infant	

(Note that the same digits are never repeated: There is, for instance, a "47," but no "74"; nor any "44" or "77"—no distinction being possible when both digits are in the same column. This same fact accounts for the application of the formula for combinations rather than permutations.)

b) *Variable number of punches:* A combination multiple-punch code, similar in nature, but utilizing the principle of geometric progression, has been published by Halbert L. Dunn for the Mayo Clinic.[1] It differs from the above, in that the number of punches per column ranges from one to twelve, thus allowing for 4095 ($2^{12}-1$) items per column. It is necessary with this code first to translate the data into numeric form, then to consult a pre-arranged table for the combination of punches representing the code number, and to perform the reverse operation in decoding. See code herewith:

Card punch	*Number in the geometric progression*
Y	2048
X	1024
0	512
1	256
2	128
3	64
4	32
5	16
6	8
7	4
8	2
9	1

[1] "Adaptation of New Geometric Code to Multiple-Punching in Mechanical Tabulation," Halbert L. Dunn, *Journal of the American Statistical Association*, September, 1932. (Excerpts from this article appear in IBM *Pointers* No. 111, "A Geometric Code for Card Expansion".)

Each number from 1 to 4095 can be formed by only one combination of punches.

(Most remarks—with few exceptions—in this article pertaining to TYPE III*a* codes are equally applicable to this kind of code.)

COMPLICATIONS IN MACHINED PROCEDURES RESULTING FROM THE USE OF MULTIPLE-PUNCHING

A. *Key-Punching:*

a.) *Numeric key-punch:* The carriage of this machine is devised so as to advance one column after depression of any punch key (or the space key). To punch more than one hole in the same column, it is necessary to either

1) depress the space key and hold it down (to arrest the carriage) while the desired punch keys are depressed in succession, or

2) push the carriage back one column before punching another hole in the same column, or

3) depress simultaneously the several keys for all the punches required in a particular column.

Method (1) is well feasible and the most common practice. However, depression of the space key on this machine is a mechanical (not electrical) operation, and if necessary for a prolonged period of time has a very tiring effect on the key punch operator, causing a marked decrease in efficiency. Since it calls for retention of the thumb on the space key while multiple-punching, it impairs the free movement of the other fingers to the keys which must be depressed while the space key is held down.

Method (2) is simple but cumbersome, and calls for care in assuring that the carriage is reversed exactly one space.

It should further be noted that—except with method (3)—the master rack of a numeric electric duplicating key punch is of no avail when wishing to reproduce multiple-punched information from a master card into all details. If a card in the master rack contains more than one punch in a column, the carriage will stop when that column is reached. It is then necessary to raise the master rack door, move the carriage back slightly (less than one space—just enough to release the keys jammed by the interlock mechanism) and punch by hand, using either method (1) or (2).

Method (3) is appropriate with mechanical key punches, which are, however, rarely used nowadays. With an electric punch, it requires the more or less permanent removal (by IBM Customer Engineering De-

partment) of the interlock mechanism. This mechanism is normally installed to prevent the ACCIDENTAL punching of more than one hole in a column; since punching on these machines is electro-magnetic, a relatively light touch of a key can cause punching. The keys are close together, and it is not uncommon for an operator to touch an unwanted neighboring key. The interlock mechanism prevents the operation of this slightly-hit key while the correct one is being pressed. Proposals to remove the interlock mechanism should be considered with hesitation—particularly as it cannot be made operative or inoperative at will at a moment's notice. Furthermore, it is very difficult to depress all keys sufficiently *simultaneously* to insure punching in the same column.

A further objection to a method calling for simultaneous depression of several keys is its interference with the "touch-punch" system, in which each key is operated by a definite one of three fingers. If two keys, both normally operated by the same finger—say a 4 and a 7—are to be pressed at the same time, the operator cannot adhere to the blind punch system.

b) *Alphabetic electric key-punch* (The discussion will be confined to numeric punching on the alphabetic punch, since these multiple-punch problems are unlikely to arise with alphabetic data).

Since spacing on this machine is an electrical operation, it is not possible to hold the carriage on a column by keeping the space key in the depressed position. These are the alternatives:

1) Holding the carriage in the position of the one column while the appropriate keys are depressed successively.

2) Identical with method (2) above, for numeric key punches. (In the case of the printing punch, the backspacer is used instead of pushing the carriage back manually.)

3) Identical with method (3) above, for numeric key punches.

The same remarks apply to methods (2) and (3) here as to the equivalent ones for numeric electric key punches.

Method (1) calls for the installation of a special device on the alpha betic printing punch—preferably foot-operated. Depression of this knob holds the carriage in the position of that particular column until released, when it advances one position. On the 031 punch, the space key UNDER THE COVER can be held down manually, as on a numeric punch.

Multiple punches prevent duplication from the master rack on alphabetic as on numeric duplicating key punches, unless the interlocking

device has been made inoperative. (However, if there are only two punches in a column, one a zone punch and the other numeric, the alphabetic duplicating punch will duplicate them, because this is tantamount to an alphabetic letter.)

B. *Verification:*

a) *Numeric verifier.* This machine is designed to test the correspondence of one hole in a card column with the key depressed, by allowing the carriage to advance to the next position only when such agreement exists. So long as one punch per column checks upon verification, *disagreement of additional punches in the same column will not be detected.* It is true that, whenever a key is depressed in verification and there is no corresponding punch in the card column, the upper end of the plunger operated by key depression will rise slightly to the surface of the key punch mechanism cover (metal plate immediately to the left of the keys). This rise is, however, barely perceptible, being limited to a small fraction of an inch—it would certainly not be noticeable to a fast "touch" operator whose eyes should be upon the source material and not the keys. When operating a verifier which uses mechanical key depression, discrepancies can also be detected by the "feel" of the key by an experienced operator. At best, it is a highly subjective criterion. (The usual three methods of depressing all keys for a multiple-punched column can be made use of, and the same remarks apply as under section A (KEY PUNCHING), except that the numeric verifier normally has no interlock mechanism, depression being mechanical rather than electrical. With method 2, however, verification would be more nearly satisfactory, since each intended punch would be tested, though it is the most cumbersome method.) There is no indication whatsoever, if some of the punches are not checked at all. E.g., if there are 4 punches in the column and the operator verifies, say, 3 only, the 4th will pass unchecked.

This method of verification (by numeric verifier) is thus highly unreliable. It retains some value (i) for verification of single-punched portions of a card which may also contain multiple-punched sections, and (ii) for detection of *completely* erroneous punching in a multiple-punched column.

b) *Alphabetic verifier:* On this machine, the error light will indicate (and the carriage will fail to advance) as soon as one punch is verified in a multiple-punched column. To prevent this, a special device—preferably foot-operated and similar to that discussed for the alphabetic key-punch—can be installed to prevent the operation of the error-

indication mechanism until all appropriate keys have been depressed (which is to be done as nearly simultaneously as possible, requiring removal of the key interlock mechanism if present), at which time the foot is lifted off the relay-holding knob. This is the most satisfactory check method with a verifier.

c) *Verification by Automatic Reproducing Punch Comparing Magnets:* When a No. 512 or 513 Automatic Reproducing Punch equipped with comparing magnets is available, it offers the most reliable means of verification. Instead of checking the punched cards with the verifier, two sets of cards are independently punched. Verification consists of matching the two decks column for column on the comparing magnets of the Reproducer. The machine will stop feeding and a red light will flash whenever there is disagreement between the punches in corresponding columns and cards of the two decks. The number(s) of the comparing magnet(*s*) in which disagreement was detected will "indicate." One additional feed cycle will yield the two matched cards which disagreed. Multiple-punches are as carefully checked by this technique as are single punches.

To obviate plugging of a control board each time, the "80–80" board available in most installations for reproduction and comparing column for column can be utilized. The *punch* plugging on this board is made inoperative—leaving the *comparing* function unimpaired—by setting the *left half* of the *Master-Detail* "*X*" double toggle switch on "detail" and leaving the right half on "master" (the two halves are usually connected by a sliding metal bar). It is then also necessary to set the "Selective Reproducing and Gang-Punch Comparing" switch ON (down), in addition to the "Reproduce" switch, to synchronize the two feeds.[2]

C. *Sorter:*

a) *Sorting:* The No. 080 and 075 sorters will react to the first hole in the card which reaches the brush. If the cards are fed in the normal manner (9's leading, face down), this will be the lowest punch in position in the column, i.e. the highest in number. With a TYPE I code, it is not feasible to sort the cards into numeric sequence, since some cards may belong into several groups. But it is possible to sort out all cards containing a particular punch by pushing in (towards the center) all commutator switches (opening the circuits) for lower-position punches.

1) If, in example TYPE I, all cases having received interim surgery

[2] "Checking Corresponding Punching in Card Pairs," IBM *Pointers* No. 477, March, 1946; idea contributed by Kurt Benjamin.

are wanted, commutator switches 3 and 4 should be pushed in, so that "2" is the lowest position punch that can affect the sorter magnet. Cards with only "3" or "4" punches will then drop into the "reject" pocket. If it is desired to maintain the sequence of all cards not containing the "2" for "surgery," all commutator switches except "2" (at least those for punches provided for in the code)—including those above "2" ("1," for instance) should be pushed in. The disadvantage involved in thus sorting out specific punches from a multiple-punched group is the loss of sorting checks: The cards in the "reject" pocket cannot be sight-checked or needled to ascertain that they really belong there, and that a "2" might not inadvertently have dropped into "reject." This can be a serious drawback of this type of code, particularly if no count is available. If a counting device is attached, this should always be switched on when sorting on TYPE I multiple-punched columns as confirmatory evidence that all appropriate cards have been selected [see section (b) below].

2) If the code is of TYPE II, it is merely necessary to push in the commutator switches for punches below (i.e., those higher in number) those applying to the variable being sorted into order. If the sort is to be on "education" (see code illustration), sorting is completely normal, since every card should contain one of the punches—and only one—from 4 to 9 for "education," and the sorting can be checked perfectly by sighting or needling.

If it is desired to order the cards on "sex," commutator switches 4 through 9 must be pushed in. Perfect checking is still possible, as with single-punch codes, as all cards must contain one, and only one, of the punches for "sex."

When sorting on "economic class," commutator switches 2 through 9 must be pushed in. The sorting check, again, is perfect. Alternatively —instead of pushing commutator switches in—the cards can be fed 12's leading (face up), so that the "economic class" punches become the first punches sensed at the brush, and no "lower" punch circuits need be opened. Of course, pocket numbers must then be reversed—12's will stack in the "9" pocket, etc. If the code happened to read just Y, X, and O (omitting the "1" in our example), the cards could be fed in the usual manner and, in place of pushing in nine commutator switches, the same result could be attained by setting the alphabetic sort switch on "zone."

3) To sort cards with multiple-punches of TYPE III, the cards are fed 9's leading, *face up*, so that column 1 is in the position normally occupied by column 80. (This necessitates compensating in the column number when setting the brush. For instance, when sorting on column

21—as in the example cited—set the brush on column 60.) After the first sort, remove the cards in the "9" pocket, letting all others remain in their respective pockets; push in the "9" commutator switch; re-sort the cards taken from the "9" pocket. Remove all cards in the "8" pocket, leaving others undisturbed in their respective pockets (there should, of course, be none in the "9" pocket at this stage); push in the "8" commutator switch (still leaving the "9" commutator switch pushed in); re-sort cards taken from the "8" pocket. Continue until all cards are in the "12" or "reject" pockets. Place deck in the "12" pocket ahead of the cards in "reject."

The cards are now in order by multiple-punch code—if the code is of TYPE III*b*, the cards will thus also be grouped, but not in strict ascending order. The accuracy of sorting can be verified by needling or sighting cards in single groups. The task of separating the groups manually is simplified if tab index cards appear ahead of each group. This can be achieved by placing a set of tab index cards, punched in the same columns with the relevant punches (one card for each possible combination of punches) on top of the entire deck of cards (so that they enter the sorter last) when commencing the sorting operation.

To summarize: Multiple-punching involves primarily a loss of sorting checks in the case of TYPE I codes; it involves the very minor inconvenience of possible manipulation of commutator switches with a TYPE II code; with a TYPE III code, the sorting can be checked adequately, but the entire sorting and checking operation is cumbersome. However, only sorting on a TYPE I code multiple-punched column—unfortunately the most common variety—is subject to uncontrollable errors.

b) *Counting:* Contrary to the sorting mechanism, the (Veeder) counting device attached to the No. 075 sorter reacts to all the punches in a column (unless deliberately modified); i.e., if a "2" and a "3" both appear in the column being counted, the card will add into both the #2 and #3 counters.

1) It has become extremely popular in research studies to utilize codes of TYPE I, and to call for extensive counting operations on the sorter, because of the convenience of obtaining a complete count, including duplication due to occurrence of several of the items simultaneously. Unfortunately, this sorter counting device is not always entirely reliable, and some check is imperative! When only one punch appears in a column (as with all single-punch codes), the aggregate of the individual counter totals must equal the total in the card-count counter. This essential (partial) check is lost with a TYPE I code, shedding doubt

upon the advisability of utilizing the counting device with such a code.

2) Some advantage actually attaches to the use of codes of TYPE II when desiring to count on all variables in the column, since the counting device will supply the totals for all items in the column simultaneously. Thus, in this example, "economic class," "sex," and "education" would all be counted during one pass of the deck, saving much time. A (partial) check is available, in that the totals for all punches of *each* variable should tally with the card count. In the case illustrated, the totals of counters Y, X, O, and 1 should add up to the number of cards in the deck; similarly for counters 2 and 3, and for counters 4 through 9.

3) The only manner in which groups of TYPE III code can be counted on the sorter is by feeding one group at a time, after they have been sorted.

3b) It may be very valuable to count on columns punched with codes of TYPE III*b*, where the sum of all the punches of the geometrical progression code can yield sums of amounts.[1] As is apparent from the illustration, each punch always stands for a definite number. If amounts, such as dollars, are thus multiple-punched, and a count of the number of cards containing each punch is obtained, the sum is computed by multiplication and addition of the totals. For instance, if there are two Y's, six 5's and one 9, the counters assigned to these three punches should have totals respectively of 2, 6 and 1. *Y* represents 2048, 5 stands for 16, and 9 for 1. The sum, thus, is 4096 plus 96 plus 1, i.e., 4193. No count check is, however, available. (See also section on Tabulator—Addition, below.)

D. *Automatic Reproducing Punch:*

Multiple punches cause no specific difficulties in the use of this machine, except for their interference with the utilization of the "double punch and blank column detection" device, which can be installed to aid in the detection (indicated by a special error light and the cessation of feeding) of cards containing more than one punch in any one or more columns, up to a maximum of twenty columns, switches being provided to signal, if desired, also cards in which selected columns are blank.

The unit was devised specifically for use in conjunction with the mark-sensing device, by means of which cards are automatically punched as directed by the position of soft lead pencil marks. Thus, persons dealing with prime sources of data are enabled to code these directly on puch cards. Since the mark-sensing unit may react to stray

[1] See footnote 1 on page 49.

pencil marks, or fail to respond to improperly-drawn lines, double-punch and blank-column detection is essential. Multiple-punch codes—which would always elicit double-punch stop signals—thus eliminate mark-sensing, and any other application of the "double-punch and blank-column detection" unit, such as might otherwise advantageously be made to interspersed master gang-punching.

E. *Collator:*

This machine was designed primarily for operations involving comparisons of the size of numbers. This function becomes limited when more than one punch appears in a column. The Collator reads only the lowest punch in a column. No distinction would thus be made between, say, 48 or 28 when punched in one column, the "8" being read by the machine in both instances. In any case, the Collator will never distinguish between O, X, Y and blank (except that X's can be used to control *X*-selectors). (If the cards are fed in reverse order—12's leading—it will, of course, be 9's, 8's, 7's and blanks which are not distinguished from each other; the "lowest" punch in this case becomes "12" rather than "9".)

1) Thus, if it is desired to "pull" cards containing a specific punch in a multiple-punched column, this cannot be done for codes of TYPE I, since the desired punch, say "2," may sometimes be the lowest punch —in which case it would be selected as desired—and at other times may be accompanied by a lower punch, say "4"—which latter would be read by the magnets, causing the card to be passed as a "no 2" case.

2) For codes of TYPE II, the Collator can be relied upon for pulling of a specific number (or for matching and merging), if certain prerequisites are satisfied:

Only one punch can appear in the positions assigned to the variable, and this variable must occupy the lower positions, as is the case with "education" in the example of a TYPE II code—i.e., the lower punches (4 through 9) all apply to this variable, and only one can appear in a card. It is, however, impossible to perform a similar selection on "sex," since there is always a lower punch representing "education."

It is feasible at times to convert an upper punch into a lower one (as mentioned previously), by feeding the cards 12's leading (instead of 9's). A specific punch of "economic class" could be selected by turning the cards over in this manner, so that Y becomes 9, X becomes 8, etc.

3) TYPE III codes cannot be handled on the Collator, unless the lower (or upper) punch by itself has some meaning (in our illustration, the upper punch represented a broad grouping).

The *Collator Counting Device* is similarly affected when controlling its operation from punches in the cards.

F. *Interpreter:*

a) *Numeric interpreter:* Cards are normally fed into this machine 12's leading, so that the upper punch is the first one read and the one which will activate the printing mechanism.

1) The interpreter will be of no use in printing the punched data for codes of TYPE I, where more than one punch may or may not occur, unless printing of the upper punch is adequate.

2) If the code is of TYPE II, the interpreter is of normal value for printing the punches in the upper positions—"economic class" in our example (special typebars are required to print Y and X if the code utilizes these positions). It cannot be used to interpret the items occupying the lower punch positions ("sex" and "education"), unless the cards are fed 9's leading, a printed Y then being understood as a 9, etc.

3) It will generally be useless for TYPE III Codes, unless the code be so constructed that the upper punch by itself has some significance (as is the case in the categorization of the example above—"occupation"—the upper punch representing the broad classification), so that its interpretation would be of limited value. If Y and X punches are used (in a non-alphabetic sense), special typebars must be installed to interpret them.

b) *Alphabetic interpreter:* All the remarks made above apply equally to this machine. In addition, it must be borne in mind that the alphabetic machine reads the upper zone punch as well as the upper numeric punch. Alphabetic letter may thus be the result of multiple punches. In the example of a TYPE III multiple-punch code, "occupation—Accountant (X3)" would result in the letter "L." (If the code consists of, say, four punches per column, e.g., X356, the letter "L" would still result.) It is possible to make zoning for alphabetization inoperative for Y and X over-punches by plugging through the X-eliminator and plugging the latter ON. This, however, still permits zoning from "0" (zero) punches, and prevents interpretation of the Y or X punches in the same typebar. The X-elimination unit also makes possible the interpretation of data in positions 0 through 9, if an item occupying the Y and X positions is to be ignored. E.G., assume the following TYPE II code:

1) Sex: Y–Male
X—Female

2) Number of dependents: 1-1
2-2
.
.
9-9 or over.

Number of dependents can be interpreted by wiring through the X-eliminator.

G. *Alphabetic Tabulator No. 405:*

a) *Listing:* The typebars stop, to rise when the first punch is sensed. Thus, normally, the lower punch in a column determines what is listed. If, among the additional punches, there is a zone punch (Y, X or 0), an alphabetic letter results in the alphameric section of the print unit, if the typebar is wired to zone. The letter will be the one appropriate to the lowest numeric and zone punches in the card column.

If the code is of TYPE II, "education" would print satisfactorily. If the cards are fed 12's leading, "economic class" would indicate. In this case it would, however, be necessary to substitute "Y" for "9", "X" for "8," etc.

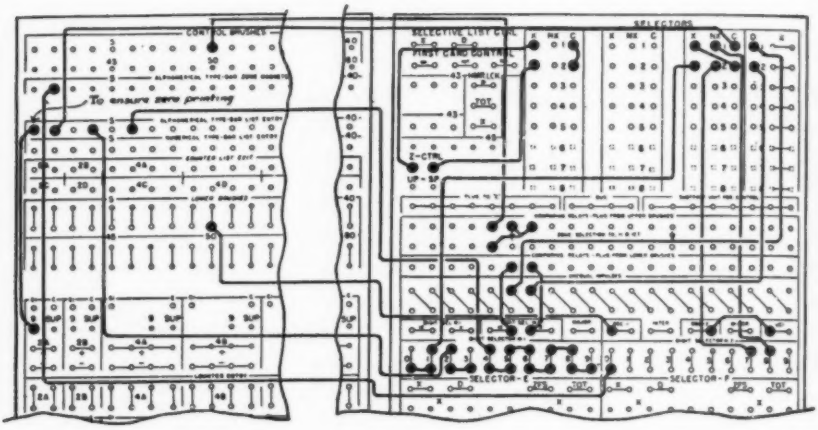
If it is desired to list all three sets of data (as illustrated in our TYPE II code), the appropriate card column can be "broken" into three sections—a typebar being assigned to each—via a digit selector, so that only one impulse per card reaches each typebar—see Diagram I (printing of Y and X punches presents its own problems not due to multiple-punching, but a method is nevertheless shown in the diagram). This principle can be expanded to assigning one typebar per possible punch and plugging through the digit selector (in this case, each digit emitter is plugged to a separate typebar), to take care of TYPE I codes—see Diagram II.[1]

Codes of TYPE III can be listed—all the punches of the column printing in adjacent typebars—as shown in Diagram III (selectors D, 1 and 2, and digit selector #1 take care of printing for Y and X punches). It is necessary that the ZFS operate the class selectors within one cycle-point, which is standard arrangement on all later models and can be easily adjusted for older machines by removal of a timing cam. (The method here described was devised by the author and has not yet appeared in print.) The principle is that a selector operated via its ZFS hub by one digit, say 9, will be in controlled position by the time the next digit reaches the add brushes (say, 8), thus distributing the lat-

[1] "Printing from a Multiple-Punched Column," IBM *Pointers* No. 215; Contributed by J. L. Trudell.

DIAGRAM I

LISTING TYPE II CODE, WITH PROVISION FOR PRINTING Y AND X



(See illustrations in article for digits used in the code.)
Note: Raise hammerlock lever for alphamerical type-bar 1

ter—the digit lower in number than the preceding—to the typebar immediately to the left of that containing the first digit. And so on. Special plugging is required to accommodate Y and X punches, as illustrated.

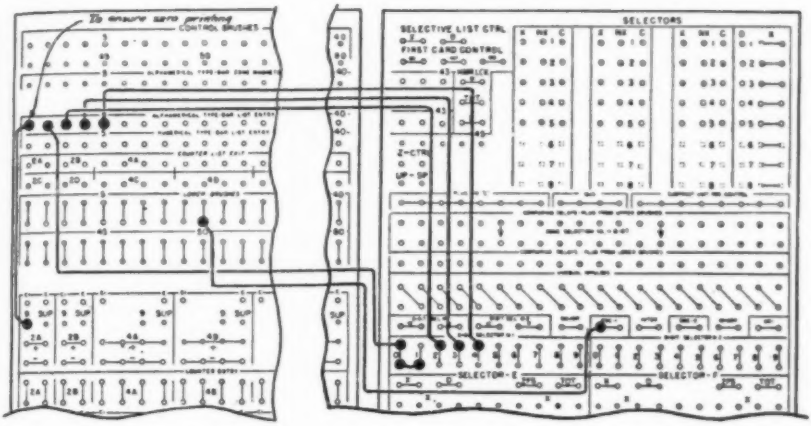
b) *Addition (and subtraction, which is addition of complements), or "counter-listing":* Counter operation also is controlled by the first punch sensed. Thus, codes occupying the lower positions of a column —such as "education" in the TYPE II example—can be added or subtracted in the normal manner. If it is desired to add or subtract an upper punch code (or to counter-list it), plugging should be from add brush via a digit selector to counter entries—the numbers belonging to one variable in the code, such as "2" and "3" for "sex" wired to the same counter entry. Vide Diagram IV (principle as in Diagram I for listing).

Addition of TYPE I codes can be accomplished by assigning one counter group to each possible punch and distributing to the counters as explained in section (a) "listing," where a similar principle is used with typebars (refer to Diagram II).

It would appear pointless to add or subtract codes of TYPE III*a;* however, the principle illustrated in Diagram III for listing such codes can be applied to distribution to counter entries, and the several counter totals added.

DIAGRAM II

LISTING OF TYPE I CODE



(See illustration in article for digits used in the code.)
Note: Raise hammerlock lever for alphamerical type-bar 1.

The multiplication necessary to obtain a sum with a TYPE III*b* code on the counter-sorter (see discussion in section on counter-sorter), can be saved, with the tabulator, by wiring in accordance with Diagram V, by means of which the actual geometric progression value for each punch is entered into the appropriate counter group, rather than a mere count, and the several counter totals merely need be added together.

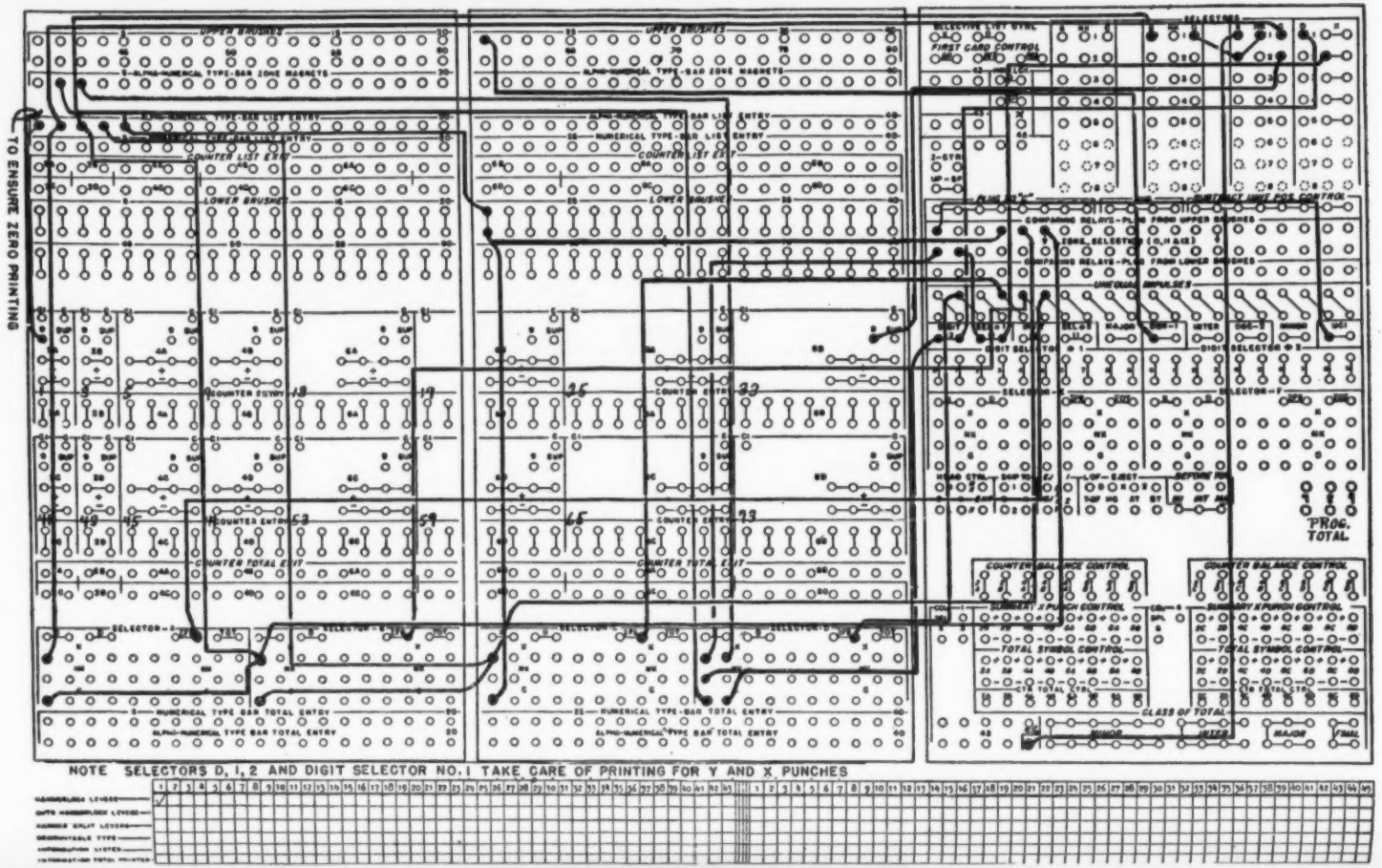
c) *Automatic control:* The comparing unit of the No. 405 alphabetic tabulator will "read" only the lower (in card position) of several numeric punches in a column. Another comparison will be made on the "X" and "Y" zone levels. No comparison is made at 0 (zero) time. This is adequate control for single-punched columns and for alphabetically double-punched columns. If more than one numeric or zone punch may occur in the column, special wiring is required to ensure differentiation of the groups.

With codes of TYPE II, normal control wiring is adequate for the lower-punch variable—"education." Control on an upper punch can be achieved (even simultaneously with lower-punch control) in the manner previously illustrated by this author in IBM *Pointers* No. 449, December, 1944.[4] A relevant excerpt is reprinted below:

[4] "Automatic Control by Two's, Five's and on Multiple-Punched Columns," IBM *Pointers* No. 449, December, 1944; idea contributed by Kurt Benjamin.

DIAGRAM III

LISTING TYPE III CODE, WITH PROVISION FOR LISTING Y AS A AND X AS I

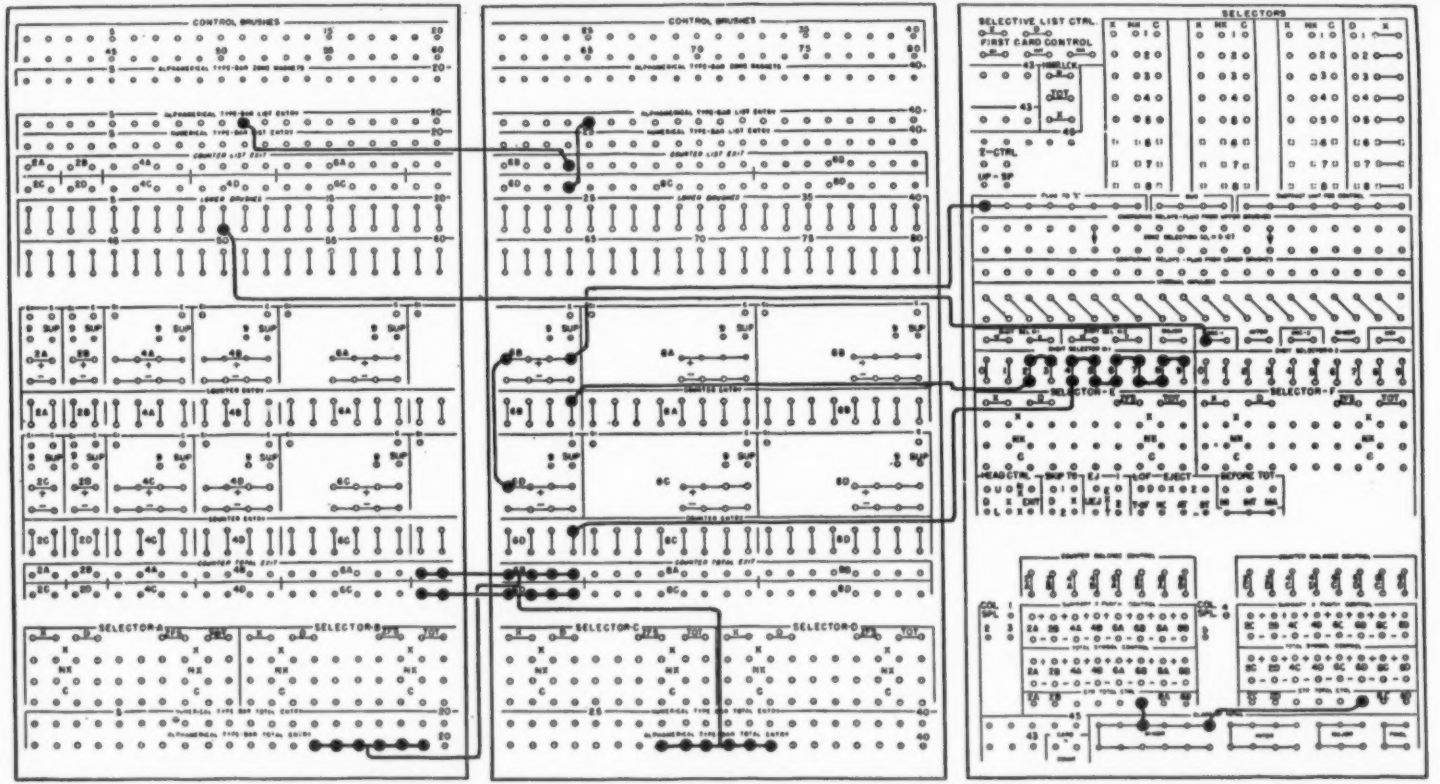

TO ENSURE ZERO PRINTING
UPPER BRUSHES
LOWER BRUSHES
COUNTER LIST EXIT
COUNTER ENTRY
COUNTER TOTAL EXIT
SELECTOR
NUMERICAL TYPE-BAR TOTAL ENTRY
PROG. TOTAL
NOTE SELECTORS D, 1, 2 AND DIGIT SELECTOR NO. 1 TAKE CARE OF PRINTING FOR Y AND X PUNCHES

(11 special type bars are installed in positions 8 and 9. Y and X can be listed correctly.)

ADDING AND COUNTER-LISTING TYPE II CODE

(If special score bars are installed in positions 2 and 3, Y and X can be listed correctly.)

ADDING AND COUNTER-LISTING TYPE II CODE

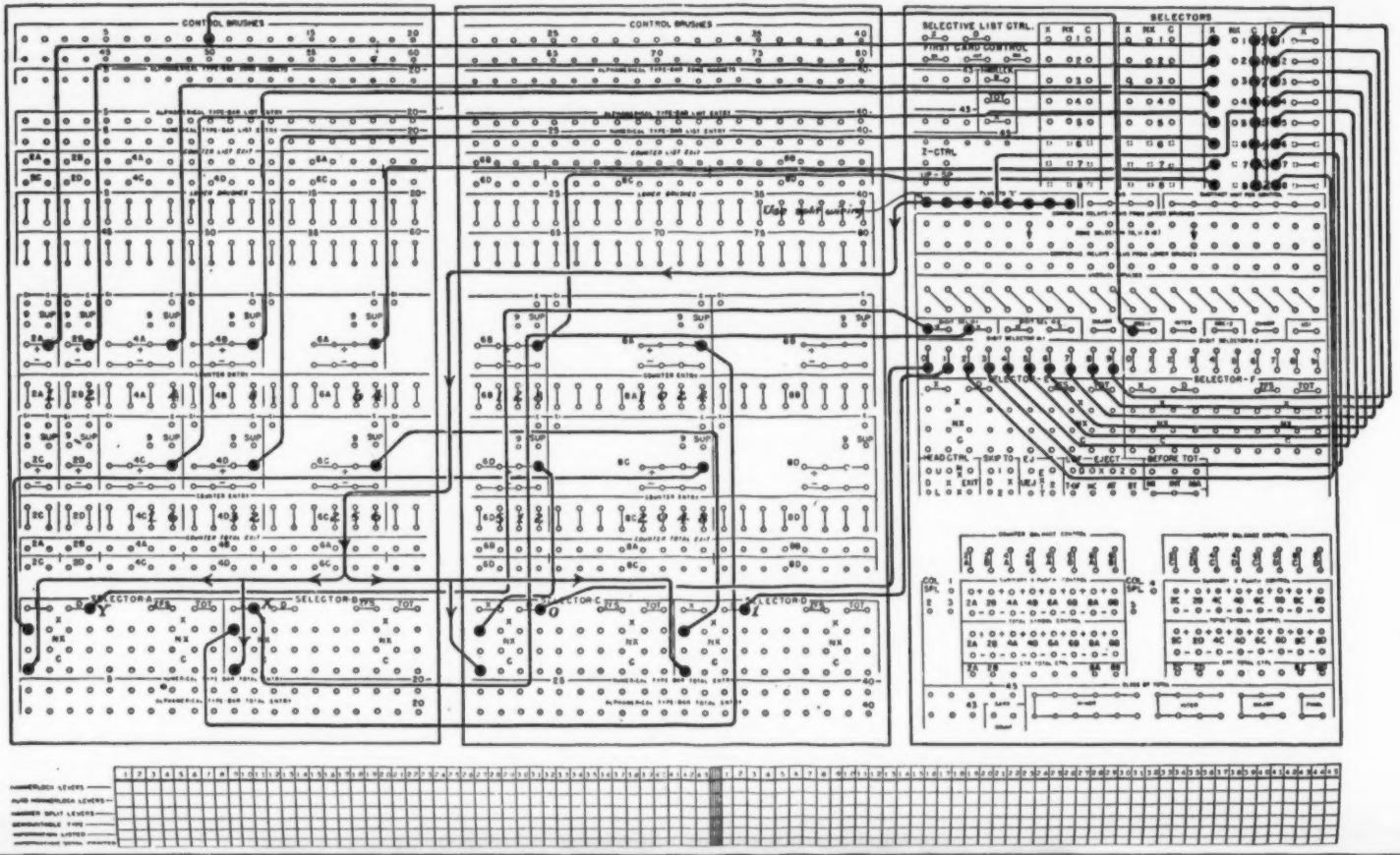


(See illustrations in article for digits used in the code—Y and X cannot be used as such.)

DIAGRAM V.—TYPE III-B CODE

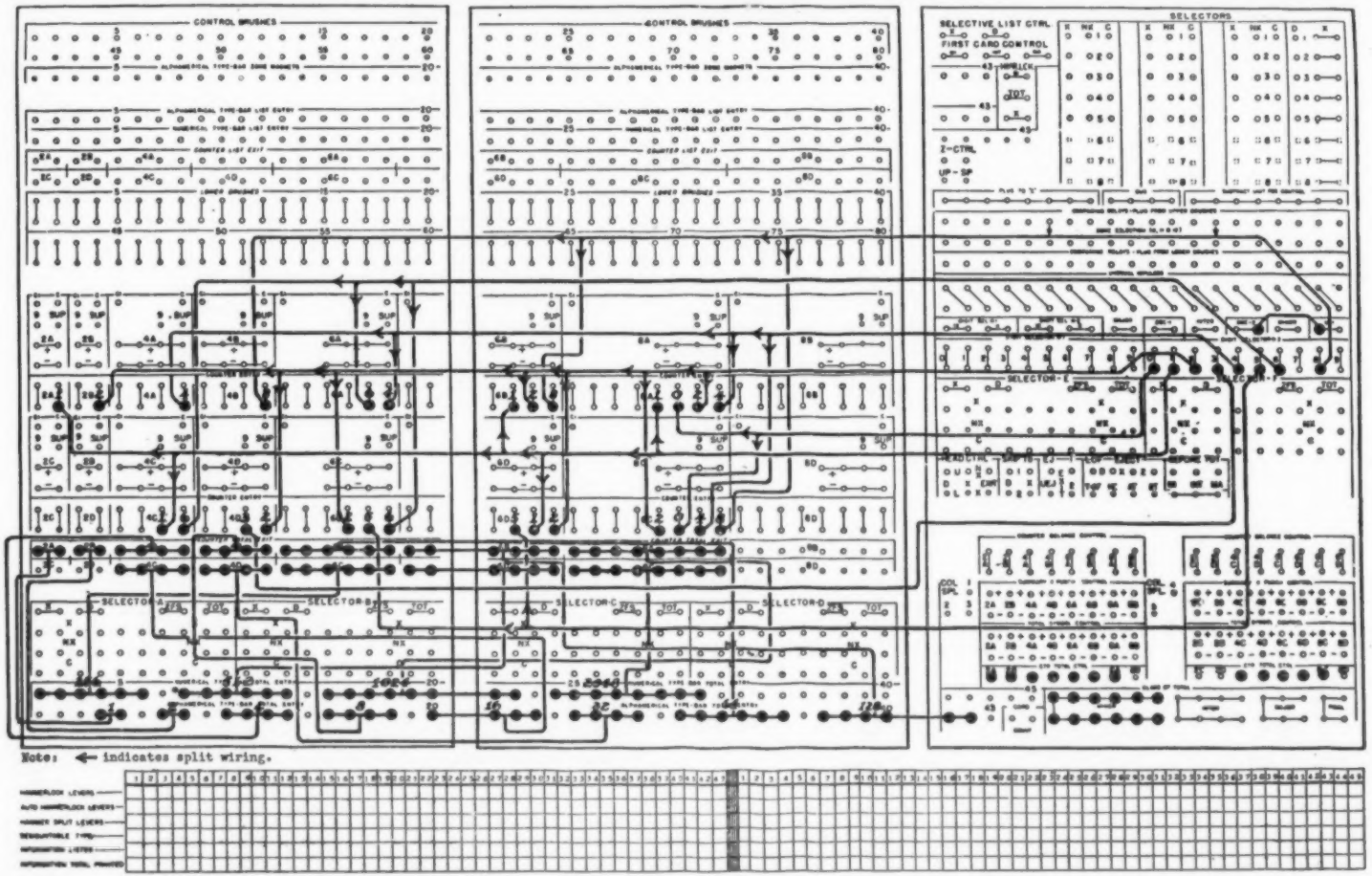
ADDING PRE-DETERMINED VALUES FOR GEOMETRIC CODE PUNCHES (SEE EXAMPLE IN ARTICLE)

PART I: WIRING FOR DIGIT SELECTION FROM DIGIT SELECTOR #1



PART 2: WIRING FROM DIGIT SELECTOR 2 TO COUNTER ENTRIES, FROM COUNTER TOTAL EXITS TO TYPE BARS, AND FOR TOTAL CONTROL

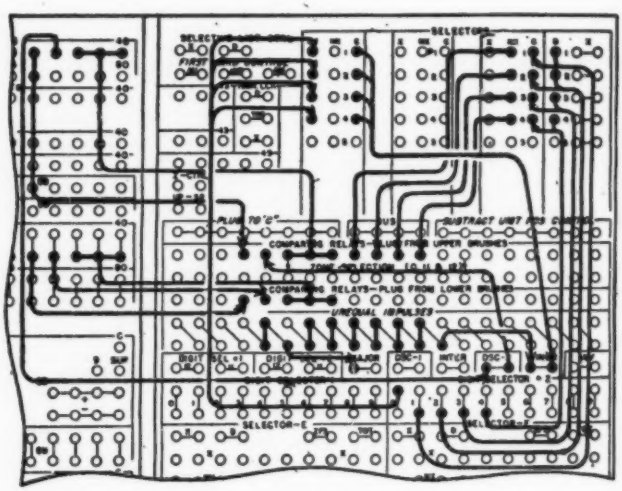
PART 2: WIRING FROM DIGIT SELECTORS 2 TO COUNTER ENTRIES, FROM COUNTER TOTAL EXITS TO TYPE BARS, AND FOR TOTAL CONTROL



Note: ← indicates split wiring.

"Sometimes split columns are used to increase the capacity of Electric Accounting cards. When e.g. the number of customers is under 5000, the digits 5 through 9 of the thousand column may be used for another classification e.g. for identification of the unit's column of the Salesmen's Field if there are more than 9 but less than 50 salesmen. By the plugging shown in Exhibit C Minor and Major Control may be applied on the split column for the upper and lower part respectively. When an upper digit is zero it must always be punched in the split column. The cards are normally sorted from right to left, not including the split column. Then the 5-9 Commutators are switched off and the cards are sorted on the 1000's column of customer number. After that the commutator switches are set to normal and the sorting is continued for the major classification of the unit's and ten's column, the former being the lower part of the split column; of course the machine ignores the upper holes in that column. After sorting, the cards are placed in the Alphabetic Accounting Machine which is plugged as mentioned above ac-

EXHIBIT C



cording to Exhibit C. When the first card of a minor group passes the upper brushes the upper digit of the split column sets up its X-Selector as explained in Exhibit A. As long as identical digits pass the upper brush, the control is maintained. However, when a different digit is read, a Minor Control break occurs. The Major Control for the lower part of the split column is normal; any change in this group causes a control break."

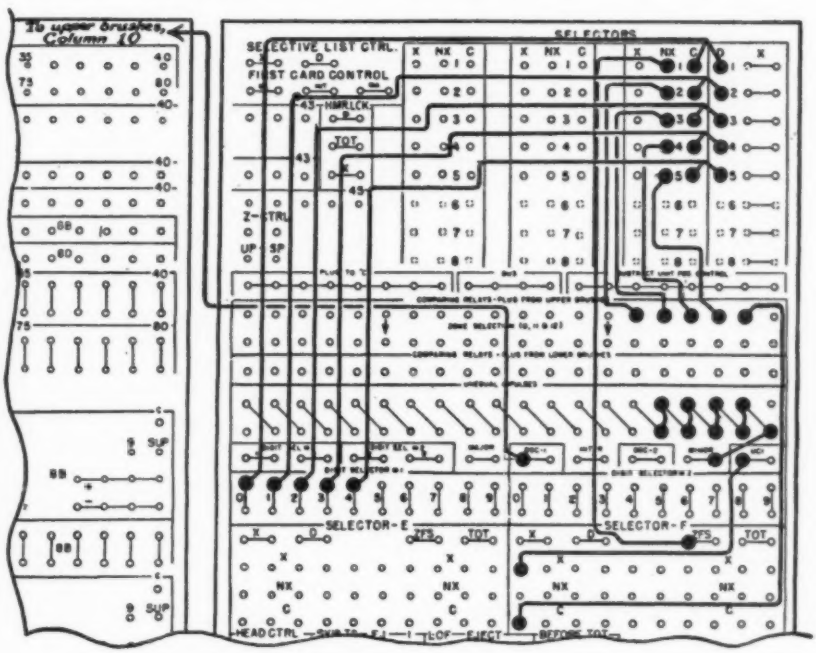
The same principle can be applied to codes of TYPES I and III

provided 0 (zero) is not used in the code. Zero punches may be employed if the plugging is modified in accordance with Diagram VI. It is then, however, necessary that the ZFS be the newer type which operates the selector within one cycle-point and accepts any punch (older machines can readily be adjusted by removal of a timing cam).

Note: Listing, adding and controlling on the upper punches of a TYPE II multiple-punch code can also be achieved by substituting for digit and class selectors appropriate column splits, which will di-

DIAGRAM VI

AUTOMATIC CONTROL, TYPE I AND TYPE III CODES—
BEING AN EXTENSION OF IBM POINTER NO. 449



This illustration utilizes the Type I code in the article, but assumes the possibility of a code in which Zero (0) may appear in conjunction with any of the other punches.

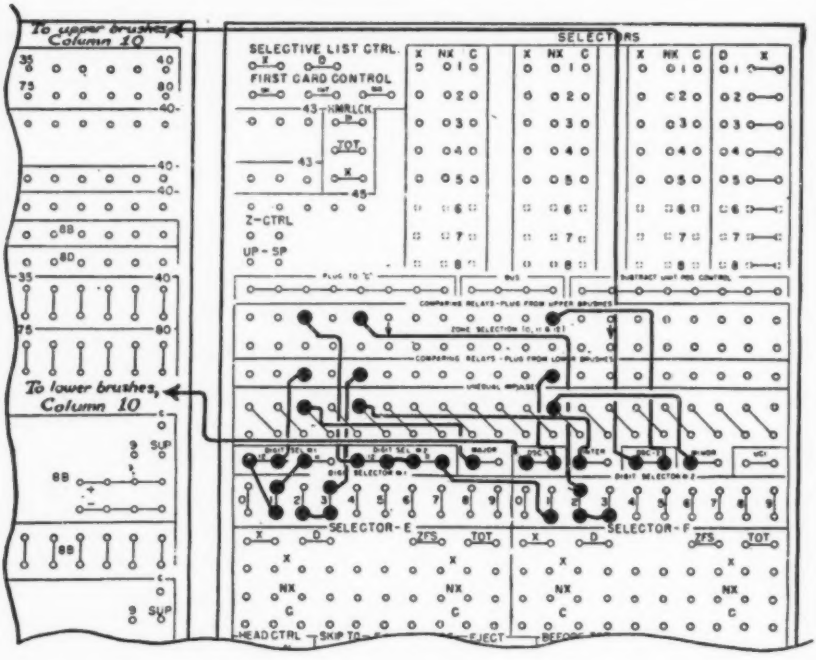
vide the column at pre-determined points. Thus, the impulses reaching a typebar, or a counter, or the comparing unit can be limited to, say "2" and "3" for "sex" in our illustration, by installing a column split with those timing limits and wiring through it (for automatic control, two identical column splits are required—for plugging from the control

and add brushes, respectively). Column splits are not satisfactory for codes of TYPES I and III, since the latter involve no *pre-determined* division of the column. Even for TYPE II codes they are rigid, whereas the digit selector allows complete flexibility.

Two digit selectors can be substituted with a TYPE II code for one digit selector plus X-distributors or class selectors (see diagram from *Pointers*, No. 449) in case an insufficient number of selectors is available, although two digit selectors may be at hand (see Diagram VII). The principle involves selection of punches which are to reach each side of the comparing unit in accordance with the variable on which control

DIAGRAM VII

AUTOMATIC CONTROL, TYPE II CODE, SUBSTITUTING SECOND DIGIT SELECTOR FOR X-DISTRIBUTORS OR CLASS SELECTOR

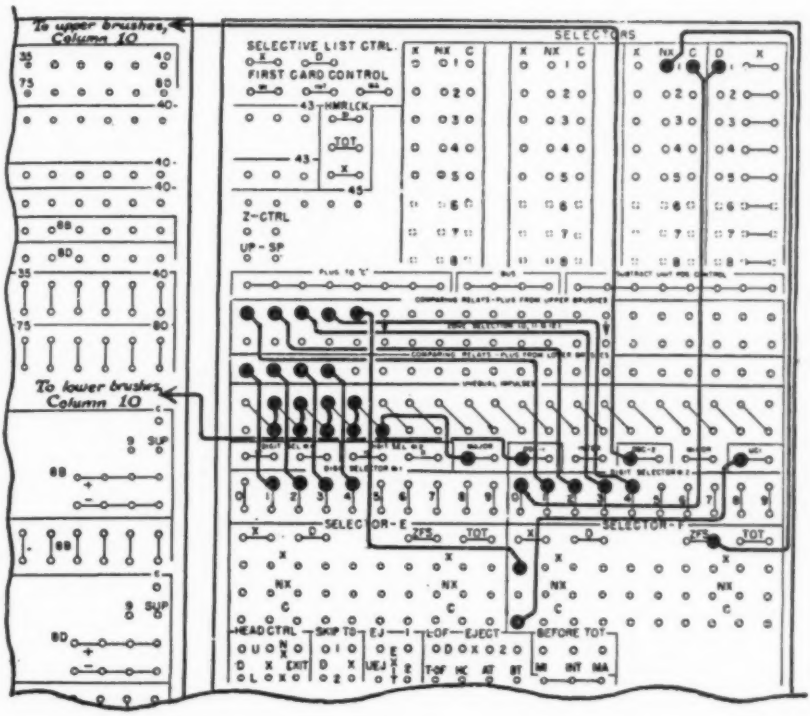


is desired. One digit selector is used for each of the two sets of brushes, and only one punch will then enter each side of the comparing relays, because of the nature of the TYPE II code (except that the lower punch code may be plugged directly). This is tantamount to the adaptation of the digit selectors to the function of column splits.

Two digit selectors can also be used to control (without use of class

DIAGRAM VIII

AUTOMATIC CONTROL, TYPE I AND TYPE III CODES, SUBSTITUTING SECOND DIGIT SELECTOR FOR X-DISTRIBUTORS AND CLASS SELECTORS



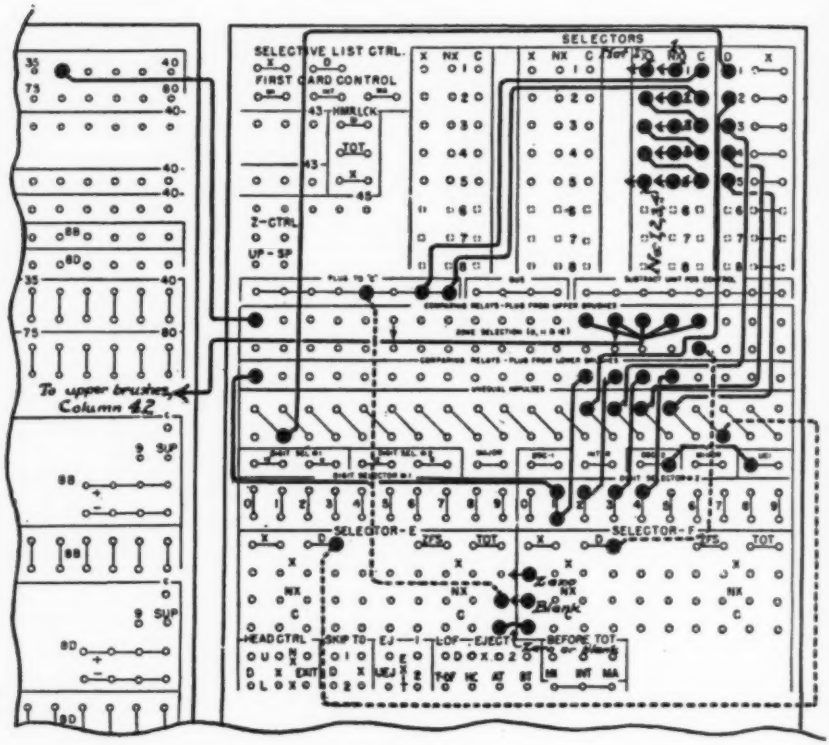
(Using Type I code in article, but making special provisions for codes in which Zero (0) may occur in conjunction with other punches.)

selectors or X-distributors) on codes of TYPES I and III, as per Diagram VIII. The digit selectors here distribute each possible digit to a different comparing relay. Any punch which is not to affect the control can be omitted from the plugging to the comparing unit (An X-distributor plus class selector are required to take care of zero punches in the code—and the ZFS must be of the newer type, as previously explained).

D) *Multiple-column independent digit selection:* A digit selector employed in the normal manner will function equally well with a single-punch as with a multiple-punch code: i.e. if each particular punch is to activate a different selector, the presence of two punches in the same column will merely activate two selectors (provided the digit emitters

DIAGRAM IX

INDEPENDENT DIGIT SELECTION ON TWO (OR MORE) COLUMNS WITH ONE DIGIT SELECTOR WHEN THERE IS NO MULTIPLE-PUNCHING



(Assumes code example in body of article.)

(Selectors E and F, and dotted lines allow for differentiation of Zero (0) from Blank.)

(In order to save selectors, it is assumed that, if conditions $a, b, \ldots r$ do not pertain, then condition $(r+1)$ applies; i.e., "No a," "No b," etc., implies "c.")

Note: +● Indicates wiring to plus or minus hubs of a counter.

for both digits are wired to the digit pick-ups of two different selectors).

Frequently, only one digit selector is available, although independent digit selection on more than one column is desired. Assume, for instance, that "sex" appears in column 36 (1—male, 2—female) and "marital status" in column 42 (say, 1—single, 2—married, 3—widowed, 4—separated, 5—divorced). If no multiple-punching occurs in these two columns, one digit selector will serve both selections (vide Diagram IX). The principle is that of comparing the possible punches with those actually in the columns, and using the unequal impulses to signal "no

1" or "no 2," etc. The number of columns on which digit selection can thus be performed by one digit selector is limited only by the number of X-distributors and class selectors available and by the capacity of the comparing unit.

Note: 1) One class selector or X-distributor can be saved for each column, if one condition always pertains, so that the assumption can validly be made that, if the sex is not "male," it must be "female," so that only one of the two items need be selected. This saving is utilized in Diagram IX.

2) Since the comparing unit makes no distinction between 0 (zero) and blank, the dotted lines in the diagram must be added when such distinction is necessary.

If, however, one of the columns thus digit-selected may contain more than one punch so that the desired one may not be the first one "read" by the comparing unit, this principle cannot be utilized, since, in our TYPE II illustration, "sex" would not be the lowest punch, with a resultant reading of "no 1" *and* "no 2." This kind of multiple utilization of the digit selector then becomes impossible with codes of TYPES I and III, and is possible with TYPE II only if the variable being selected occupies the lower portion of the column.

e) *Summary-punching:* Anything stored in a counter of the tabulator can be summary-punched. Group-indicated data are summary-punched by adding them into counters first. The section on "addition and subtraction" should be consulted for a discussion of addition of multiple-punched data—summary-punching is subject to the limitations therein set forth.

If a multiple-punched column is to be summary-punched—as might be the case with group classification data—the punches must be read into separate counters in accordance with the directions given in the section on addition. The numbers in the separate counters can then again be summary-punched into one column by multiple-plugging on the summary-punch plugboard from the several counters to one punch magnet.

In conclusion, my thanks are due to Dr. David Schneider, N. Y. State Dept. of Social Welfare, who kindly offered the assistance of his staff in the preparation of the diagrams, and to Miss Agnes L. Rydberg, statistician, and Miss Pirie H. Perenyi, graphic statistician, who carried out the work.

AN EMPIRICAL APPROACH TO ECONOMIC INTELLIGENCE IN WORLD WAR II

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Department of State

In early 1943 the Economic Warfare Division of the American Embassy in London started to analyze markings and serial numbers obtained from captured German equipment in order to obtain estimates of German war production and strength. This report is the story of the development of this technique in terms of the problems which arose and the ways in which they were solved.

Various kinds of captured enemy equipment were studied by this technique. The first product to be so analyzed was tires, and after this tanks, trucks, guns, flying bombs, and rockets were studied. Aircraft markings were not studied by the Economic Warfare Division, since, by previous agreement, the British Air Ministry bore the responsibility for all estimates on aircraft production. The uses of the intelligence derived from the markings were varied. At times it helped decide the target systems of the air forces; on other occasions it gave indications of German strength in weapons such as tanks and rockets.

After the war official statistics on German war production became available, so that it is now possible to evaluate the accuracy of the estimates which were made. Part II presents a summary scatter diagram of the estimates and official data along with a more detailed treatment of certain estimates.

ECONOMIC intelligence in World War II played an important and varied role during the conflict with Germany. Information as to Germany's war potential was the frame of reference which shaped the pattern of allied mobilization and strategy. Knowledge of the quantities and types of war materiél possessed by the enemy was needed to fix the timing of the invasions and to plan the kind of warfare which was to be waged. In addition, both aggregative data about German industry and highly detailed facts about individual plants and products were very necessary to carry out the allied strategic bombing program as conceived at the Casablanca Conference. Behind each attack of the Eighth Air Force over Europe lay extensive research, involving such considerations as the essentiality of various German war products;

the exact location, relative importance, and output rates of various producers; the length of time elapsing between the separate production processes and consumption of the finished article by the army; substitutability of various products; the availability of alternative production facilities; and finally recuperation rates of industries suffering from direct bomb damage.

During the early phases of the war, Allied economic intelligence proved inadequate for the many needs it had to serve. Aggregative estimates of German production were based either on prewar data extrapolated according to British or American experience, or else on standard tables of equipment requirements derived from German order of battle estimates. Neither method proved reliable, because the models which were developed permitted numerous degrees of freedom which could only be restricted by using highly unrealistic or rigid assumptions. Consequently even the order of magnitude of many aggregative estimates proved to be in serious error. Data on specific plants within an industry were no better. Secret sources and interrogations yielded large masses of contradictory reports. Some of these reports undoubtedly were accurate, but it was impossible for the analyst to discover these in the flood of rumors and false statements that crossed his desk. For any plant, intelligence data could be found that would support any given output rate of a product. As a result the analyst always perforce fell back to estimating what seemed to be reasonable, so that here again intelligence was bent to the preconceptions in our own minds, rather than to objective facts.

Part I of this article describes the historical development and problems of a technique of economic intelligence which sought to overcome the basic inadequacies of other types of intelligence. This technique involved analyzing the markings found on enemy equipment in order to obtain useful information about German armaments production. In Part II, the reliability of the estimates achieved by this analysis have been assessed on the basis of official German production records which have since become available.

I

Each piece of enemy equipment, whether main assemblies or component parts, was liberally labelled with markings inscribed either on the equipment itself or on attached nameplates. Such markings varied as to completeness and included all or some portion of the following information: (a) the name and location of the marker, (b) the date of manufacture, (c) a production serial number, and (d) miscellaneous

markings such as trade marks, mold numbers, casting numbers, etc. The purpose of these markings was twofold. First, they furnished information necessary to maintain an effective check on production standards. Faulty performance of equipment in the field due to defects of manufacture could readily be traced back to the original source and corrected. Second, some of the markings were essential for proper spare parts control. However, these same markings, if subjected to proper analysis, offered Allied intelligence officers a wealth of information about Germany industry.

ESTIMATION OF GERMAN TIRE PRODUCTION

Tire Markings. The technique of analyzing these equipment markings as a source of information on German industry developed informally out of the liaison between Economic Warfare Division of the American Embassy[1] and the British Ministry of Economic Warfare. British experts working on the German rubber industry had accumulated a sample of markings from about 2000 enemy tires. These had been taken from German aircraft shot down over Britain and from supply dumps of aero and motor vehicle tires captured in North Africa. In the main, the markings had been used by the British to identify German tire manufacturers, since the maker's name was always inscribed clearly on each tire. In addition to the maker's name, however, every tire bore a serial number and a two letter code for the date of manufacture. An array of the data for each manufacturer indicated that the tires were numbered systematically. However, it was still a matter for conjecture whether or not reliable production data could be obtained by solving the date codes and relating them to the systems of numbering. The British had attempted some investigations in this direction, but shortage of manpower forced them to concentrate their energies on more immediately pressing questions. By agreement with them, a small number of American analysts were allowed to work with this sample of data.

Manufacturing dates on tires. The first step in analyzing tire markings involved breaking the two letter date codes. These codes were not used by the Germans as a wartime security measure; their purpose was to indicate to the manufacturer and dealer the date when a tire was made without revealing it to the purchaser. Since there were two letters, it was assumed that one represented the month and the other the year

[1] The Economic Warfare Division of the American Embassy (EWD) was a centralized intelligence agency in direct contact with British agencies. Its personnel consisted of analysts loaned by the Office of Strategic Services, the Foreign Economic Administration and the State Department.

of manufacture. The further assumption that there should be 12 letter variations for the month code and probably three to six for the year code also seemed reasonable if simple substitution codes were used. On this basis, the month code was distinguished from the year code by reason of its greater variation (12 variations if the sample were large enough). The fact that the tires were numbered serially helped break some of the month codes. Where the tires were numbered in a continuous increasing series, a simple array of the cases by number would reveal the order of month letters with any given year letter. If sufficient cases existed the code would be solved. Where the sample of a particular make of tire was too small for that purpose, other code solutions suggested themselves. Thus, it was apparent that some manufacturers based their month codes on words or simple arrangments of letters. Examples of this are given below:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dunlop	T	I	E	B	R	A	P	O	L	N	U	D
Fulda	F	U	L	D	A	M	U	N	S	T	E	R
Phoenix	F	O	N	I	X	H	A	M	B	U	R	G
Semperit	A	B	C	D	E	F	G	H	I	J	K	L

Month dates on tires. The Dunlop code was Dunlop Arbeit spelled backwards, and Fulda and Phoenix used the letters of the firm name and the location of the central office. Semperit employed a simple continuous alphabetical series. The largest tire company, Continental, presented a more difficult case. The letters in the month date code were sufficient to spell Braunschweig, a city where the central officers were located. However, if the sample were arrayed serially, the month code became merely an anagram of Braunschweig. This possibility appeared unrealistic at the time since the date codes were probably not intended to be so obscure as to require the use of a code book. However, if it was assumed that the cases were dated according to Braunschweig spelled either forward or backward, then production appeared to be numbered in scattered individual monthly bands rather than in one continuous increasing series. This dilemma of the Continental date code was solved only at a later date when sufficient cases were obtained to prove that the standard deviation of the gaps between monthly bands was of no greater magnitude than the standard deviation of the gaps existing between the cases within monthly bands. On this basis, it was concluded that no gap existed between monthly bands, and all tires were numbered in a single continuous series. Thus, the Braunschweig anagram as indicated by serial arrangement of the

cases was found to be correct.

Year dates on tires. The solution of year codes varied for different manufacturers. Some tire sizes (especially for aircraft) were known to be new types, and so could be dated. Other tires appeared to be part of the original equipment which itself was dated. For some companies, the year 1939 could be identified by the sharp drop in tire production consequent upon conversion to the production of military types. Once reliable dates were established for one manufacturer, the distribution of cases in the sample for other manufacturers often revealed their year codes.

Results of the analysis of tire markings. After the individual tires were dated and the numbering system solved, then production figures could be obtained. It was found that five manufacturers produced over 70% of the total German tire output. With a sample of about 1400 cases for these five producers, individual monthly output figures were obtained for each in all but a few months over a period from 1939 to mid-1943. The output of two additional manufacturers producing 10% of the total could be estimated for scattered months in 1941 and 1942. Production of the four manufacturers contributing the remaining 20% was estimated in round figures solely on the basis of their relative importance in the sample. An indication that the sample was sufficiently representative for this purpose had already been given by the fact that each major producer was represented in the sample in direct proportion to the serial number estimate of his production.[2]

After this methodology had been established by the foregoing sample of 2000 cases and a report had been issued in October 1943, systematic collection of tire markings was undertaken. By July 1944, more than 11,000 cases had been obtained. These were sufficient to raise monthly serial number analysis to a 98% coverage of the industry, and on this basis a very comprehensive report was issued. After July 1944, as new

[2] Before this fact could be determined, aircraft tires had to be separated from truck tires in the sample. Aircraft tire production as revealed by serial number analysis was 15%, but in the sample almost 50% of the markings were from aircraft tires. In other words, tires from aircraft shot down over England bulked large in the sample. Fortunately, only three German producers made aircraft tires. By separating aircraft and truck tire markings, the two samples thus appeared to represent all the German tire manufacturers in their due proportions. The first strong indication of this was the fact pointed out above that the representation of the major producers in the sample was proportional to their serial number estimates. Secondly, tire markings in the sample indicated that all known tire plants in Germany were represented. Almost all tire production was in a few standard sizes of aircraft and truck tires, so that specialized types were only a small proportion of the total output and of the sample. Factories did not specialize in certain types of tires (except as noted in aircraft tires) so this eliminated this possibility of bias. From the general representativeness of the sample it was deduced that the location of plants was not important in the distribution of tires to the various fronts. One element that would have lessened the possibility of bias from this factor was the fact that many German units went to Africa from Russia and took their equipment with them.

cases were received, periodic reports were issued bringing production estimates of individual manufacturers up to date. However, no additional studies were made covering the industry in general since enough information already had been distilled from the data to meet most of the intelligence requirements. Further overall studies would have yielded mere academic refinements without altering the basic picture materially.

Mold number analysis. Besides yielding output data, markings on German tires provided other useful economic intelligence. A special study of mold numbers on tires made it possible to estimate the manufacturing capacity by type of tire for each German producer. Manufacturers numbered the tire molds in simple continuous series usually starting with the number 1 and using a separate series for each tire size. These numbers are indentations on the inside of the mold and therefore appear as raised numerals on the carcass of the tire. With the large tire sample at hand it was possible to calculate the number of molds for each tire size which individual German producers had used. Then, using British manufacturers' experience on the daily tire capacity of a single mold, it was a simple matter to estimate the production capacity of each German producer.

The fairly accurate figures of German tire production by sizes yielded by the serial number and mold number studies also made it possible to obtain information on the rate of the enemy's rubber consumption. From markings on tires which indicated the percentage of natural rubber used, it was possible to obtain a picture of how Germany was utilizing her crude rubber stocks. Finally, the estimates of aero tire production by types provided a valuable check for analysts calculating German aircraft output.

Use of tire estimates. The chief significance of the tire markings analysis was that it afforded for the first time a reasonably accurate picture of German tire production by individual makers. This information provided a firm basis for assessing the importance of the German tire industry as an air target system. Although the initial tire study was based on a sample representing only about 3/10 of one per cent of the universe, a number of factors supported the accuracy of the findings. First, representation of individual producers in the total sample was proportionate to their production as estimated by serial number analysis. Second, the deviations in monthly output for individual producers were of reasonable relative magnitudes. They showed the period of conversion, the way in which production fell off sharply, and then built up to a level considerably below the peacetime peak. This was to

be expected since military tires are larger and more difficult to make than civilian tires. Third, production estimates for any one month well represented in the sample showed a high degree of stability even when based on only a fraction of the cases for that month selected at random.

In addition to bringing about a major revision in the aggregative tire output estimates, serial number analysis also furnished intelligence officers working on enemy target systems with a great deal of relevant material. The location and importance of each producer was now known, as well as the length of time elapsing between the manufacture of tires and their use by the army. While the first tire report was in preparation one plant was bombed. The study showed the monthly output figures for this plant before and after the attack, and thus furnished a valuable check on the results of the bomb damage.

ESTIMATION OF GERMAN TANK PRODUCTION

The significant results yielded by analysis of markings on tires indicated that the same technique might be employed for other types of enemy military equipment. The American analysts, therefore, directed their attention to markings on German tanks. Tank markings were available from a number of sources. Documents captured in North Africa included German tank log books. These books contained the chassis and engine serial numbers of the tanks to which they belonged, along with the date of manufacture and the name or code of the assembler. Papers captured at divisional headquarters sometimes included lists of the tank holdings of specific armored units, enumerating types and chassis serial numbers of individual tanks. Captured records of German tank repair depots reported the chassis and engine serial numbers of every tank repaired. Also, spare parts order books and other technical publications issued by the *Wehrmacht* listed tank chassis serial number bands to indicate exactly the various models of spare parts required for different tanks. Finally, some tank markings had been recorded in North Africa by technical intelligence field personnel inspecting captured equipment, and a few German tanks were available for more detailed examination in both England and United States. From all of these sources, about 1200 tank chassis serial numbers were obtained along with more detailed markings for a small number of vehicles.

Tank serial number bands. Unlike tires, tanks were not numbered in separate series for each manufacturer. Rather a different series was used for each type of tank without regard to the maker. Thus all Mark I tanks fell in the series 0 to 20,000, all Mark IIs in the series

20,000 to 30,000, and so on. When the cases in any particular series were arranged in an array, it became evident that some central authority had allotted the various producers one or more bands of numbers within the series. However, further analysis revealed that the bands allotted to individual producers were not necessarily fully used. When the bands were broken down by round blocks of 100 numbers, it was observed that different models of the same type tank never appeared within the same 100 block. From the point of view of facilitating spare parts control, this was logical, since tank models then could be referred to in spare parts catalogues by range of chassis numbers given in terms of round figures. It meant, however, that gaps existed between the last tank chassis number of a particular model or design and the beginning of the next hundred block. Since the Germans were continually shifting their designs and models, this fact was of considerable consequence in estimating production. The only apparent solution to this problem lay in the analysis of the distribution of the cases within each 100 block. If the non-utilization of higher numbers in the 100 blocks was significant, then a sample of serial numbers should show concentration of cases in the lower parts of 100 blocks rather than a scattered even distribution. The following table indicates that this proved to be true.

RELATIVE FREQUENCY OF TERMINAL DIGITS

	Mark I	Mark II	Mark III	Mark IV
% of cases in sample ending in digits 00–25	37	42	30	29
% of cases in sample ending in digits 26–50	28	33	27	30
% of cases in sample ending in digits 51–75	17	15	23	30
% of cases in sample ending in digits 76–100	18	10	20	11
Total	100	100	100	100

With the above table it was relatively simple to compute the degree to which the 100 blocks were utilized for the numbering of each type of tank and from this to estimate actual production. It is apparent that the sample was fairly representative of the universe of the data since although a lower quartile might be equalled it was never significantly exceeded by a higher quartile. An independent check on the accuracy of the tank production figures calculated as described above was provided by estimates of tank engine production based on engine serial numbers.

Tank manufacturers' codes. Identification of individual producers was complicated by the fact that after 1940, for purposes of security, arbitrary three letter codes were substituted for the name or trade mark of

the assembler on the tank. Fortunately, the tanks made earlier bore the assemblers' name in the clear, and thus provided a basis whereby the codes could be solved. It was observed that each assembler used a distinctive nameplate. Some firms used copper name plates whereas others used plastic, steel or zinc. The style of printing on these plates was also quite individual. Most assemblers failed to change these distinguishing characteristics of their plates when they were required to use a code instead of their name or trademark. Krupp at Magdeburg was careless enough merely to file the company name and trademark off the old nameplate and then stamp on instead the new code "bqo". Some assemblers careful enough to change the style of their plates revealed themselves by continuing to use previously identified serial bands to number their tanks. Others were identified on the basis of the *Wehrmacht* acceptance system. Every tank had to be tested by a *Wehrmacht* inspector before it was accepted. One or more inspectors were located at each tank assembly plant. These signified their acceptance of a vehicle by stamping their individual inspector's number on it. When the tank assembler's names were coded these acceptance stamp numbers were not changed, and thus provided a basis for identification of the codes. Finally, one or two assemblers were identified by the Germans themselves. The assembler's name instead of the code was written in some tank log books; even where this document had been separated from the tank, the serial number indicated the band which was used by that manufacturer, and reference to other tank chassis numbers in the same band broke the code.

Results of the analysis of tank markings. The first tank report yielded less detailed information than the tire report, but it was no less comprehensive. Annual tank production by type was obtained for the years 1939–42. The number and relative importance of the various assemblers also was determined. Analysis of tank engine markings indicated that two manufacturers were responsible for 100% of Germany's engine production. The significance of this early tank study, just as in the case of the tire report, lay in the fact that its findings differed radically from accepted intelligence. At this time the accepted estimate of cumulative total German tank production was about 40,000; serial number analysis revealed that this was a gross overestimation; not more than 14,000 tanks had been produced. The 1942 production rate, originally accepted as being about 18,000, was estimated by the serial number technique as being only 3,400. In other words, Allied intelligence still suffered from the myth of German invincibility created by Nazi propagandists out of the successful *blitzkrieg* tactics in Poland and

France, and it had grossly overestimated the enemy's position; the serial number technique revealed this fact and introduced realism in our picture of the strength of the German war machine. Furthermore the number and importance of the various producers, hitherto unknown, was now revealed.

Utilization of other tank markings. Following the first tank report, intensive examination of captured tanks revealed other markings besides chassis and engine serial numbers which proved very useful guides to estimating production. Gearbox markings were a case in point. Analysis of a sample of markings indicated that each type of tank used gear boxes numbered in either one or two simple increasing and unbroken series. This presented a very different situation from chassis serial numbers where the production series for each tank type were broken up into a large number of discontinuous bands. Accordingly relatively few cases were needed to determine gearbox production accurately since the problem of measuring the gaps in the series was obviated. Once gearbox production had been calculated, the production of tanks could be estimated, by taking gearbox replacements into account. Besides checking and improving on the accuracy of the estimates of tank output derived from chassis serial numbers, gearbox markings also provided a means of obtaining accurate tank output information on the basis of as few as one or two tanks. In short, the gearbox markings of one relatively new German tank offered the same possibilities of bringing the production estimates up to date as a large sample of chassis serial numbers from new tanks. Using gearbox markings, the November 1944 production of the Mark V tanks was known by January 1945.

Other markings on tank guns, radiators, turret motors, bogie wheels, etc., provided additional series which both increased the accuracy and reliability of the estimates and at the same time reduced the size of the sample of tanks required. Tank chassis markings showed only the year of assembly and even this date was dropped for some tanks produced during the later stages of the war. This complicated the accurate estimation of rates of production. However, component parts markings yielded a variety of month and year dates which enabled closer estimates of tank assembly dates to be made. For example, if a tank was captured at the front in December 1944 and the inspection dates on parts and components ranged from June 1944 to October 1944, then assembly probably took place in November 1944, assuming that none of the dated parts were replacements. By careful analysis it was possible to estimate the tank industry pipe line—the time elapsing between the

manufacture of the various parts and components and the assembly of the tank, and its appearance on the fighting front. In this way the depth of the process of tank manufacture in the economy could be estimated. This information was essential in assessing the vulnerability of this industry to bombing.

Analysis of bogie wheel markings. The possibilities which intensive analysis of markings on a few tanks offered are best illustrated by the case of the Mark V or Panther. Just before D-day, army intelligence became vitally concerned with the rumors of large Mark V tank production. At the time, only one Mark V tank had been encountered by English and American troops. This tank had been captured in Sicily and was shipped to England. A second Mark V taken by the Russians was also turned over to the British. Careful examination of the markings on these tanks revealed that the probable assembly date of the one from Russia was March 1943, and of the one captured in Sicily, February 1944. The Mark V tank was constructed with eight axles, each having six bogie wheels (three on each side supporting the tank treads.) In other words, there were 24 rubber bogie wheels on each side of the tank. The study of tires already had revealed the mold numbering systems of the various tire companies. On the tank sent from Russia, all the bogie wheel tires were made at one plant which possessed only nine molds. This was obvious, since, for all 48 tires, the mold numbers ranged from 1 to 9, and every number was represented from 3 to 8 times. On the second tank the tires were made by 3 different companies. The highest mold number of one maker was 77 and the average gap in the series was about 3 cases, so it was estimated that this plant had about 80 molds.[8] The number of molds for the other two companies was estimated similarly. Tank output was calculated in two ways from the number of bogie wheel molds. First, the potential production of Mark V bogie wheels from the estimated number of molds was obtained by consultation with British bogie wheel producers. A percentage of these was calculated for replacement use and the rest were assumed available for new tank assembly. Secondly, the number of existing molds was obtained for the bogie wheel tires on Mark III, IV, and VI tanks respectively. Then the relationship between the number of existing molds for each type tank to their serial number production estimates was calculated. Both methods of estimating production gave similar results. They indicated that Mark V tank assembly was at

[8] It is obvious that if there is no actual gap in the mold numbers, this estimate of 80 molds was at the most 4% too high. Since there were about 20 cases, then the probability would be 13 out of 14 that the error of underestimation was smaller than 10%. If the molds were used to capacity, then a random sample would probably exist, since they would operate at about the same rate.

a rate of 270 per month by February 1944 if tank assembly was occurring at the capacity of bogie wheel production. After the war it was found that actual production in this month was 276. On the basis of the bogie wheel analysis, probable Mark V strength was calculated, and thus the Western Allies were forewarned that they would encounter this tank in larger quantities than originally anticipated.

After the first tank report was issued, continued analysis along the lines indicated above and the accumulation of larger and more recent samples of markings yielded a steady flow of new information on German tank production. The upward trend of tank production was accurately reflected by the estimates based on markings.

OTHER ANALYSIS OF MARKINGS ON GERMAN EQUIPMENT

Refinement in the collection and analysis of markings. The work done on tank markings greatly furthered the theory of serial number analysis in general, and brought about important revisions in both the methods of collection and the analysis of data. Originally, markings had been gathered more or less indiscriminately without too much regard for their significance for purposes of analysis. Consequently, valuable markings frequently were overlooked while much time was spent recording useless information. Accordingly, steps were taken to overcome these obvious deficiencies of collection procedure. After some study of enemy equipment and analysis of their markings, forms were made up with places for forty to fifty important groups of markings on each type of equipment. Manuals with examples and photographs of each type of marking accompanied these forms so that uniformity might be achieved by the field teams. A system of filing these cards was designed in London to facilitate analysis. Charting the markings as they came in provided a method whereby any contradiction or extension of previous estimates would be immediately revealed.

Analysis of motor vehicle markings. After the experience gained on tires and tanks, the work of serial number analysis was extended to motor vehicles, guns, ammunition, special components, and finally to flying bombs and rockets. A report on German motor vehicle production, including half-tracked vehicles, based on about 4000 cases, was released in April 1944.[4] As in the first sample of tank serial numbers, the majority of these cases (75%) came from captured documents. The motor vehicle industry was more complex than either the tire or tank industries. It comprised almost 50 producers who turned out over 70

[4] This sample contained a little over 1% of total production for the time period (1942) which was most fully covered.

different models of vehicles. The estimates covered the entire industry giving annual output figures by maker for each model of vehicle for the years 1940, 1941 and 1942. The data were not sufficient to yield a full coverage of the industry for 1943. Additional cases received later extended many of the estimates, but since the salient facts about the motor vehicle industry had been revealed, there was no real need for further comprehensive studies along this line, in view of the limited strategic significance of the industry.

Analysis of gun markings. Serial number analysis of guns was not undertaken on the same broad scale as tires, tanks and motor vehicles. The German ordnance industry never was seriously regarded as a target system and the main interest in guns, aside from technical considerations, centered about production of a few special types.[5]

Analysis of ammunition markings. Analysis of markings on ammunition followed the same general lines as that on guns. Investigations were undertaken with a view to answering specific questions raised by the military rather than to providing over-all coverage of the industry. Thus at one stage of the war ground intelligence reports and prisoner of war interrogations suggested that the Germans might be suffering from a shortage of ammunition. If this were the case, some phase of the industry might offer a good target system. Determination of the length of time elapsing between the manufacture of ammunition and its consumption by the army offered a concrete method of checking on the reliability of the rumored shortages. If this time period was short, it would indicate production was used for immediate consumption and stockpiles were low. Each piece of ammunition was marked with the exact day of assembly, so the analysis of captured ammunition stocks in the various theatres shed considerable light on this question. It was found that except for a few types of ammunition the German "pipe-line" was more than adequate. The so-called general shortages, it was later determined, were caused by transportation difficulties in specific areas rather than insufficient production *per se*. In any case, the "pipe-line" analysis was instrumental in causing the ammunition industry to be rejected as a target system. Other information yielded by analysis of ammunition markings included the number and importance of assemblers and fuse makers.

Analysis of flying bomb (V-1) markings. Analysis of markings on flying bombs (V-1) was undertaken as soon as these weapons were launched against London. A special form and manual of instructions

[5] Guns had as many as six components, all of which were marked serially. This made analysis possible on quite small samples. However, the use of codes prevented the identification of some gun producers.

were prepared which provided for the recording of over 100 markings from various identifiable remains of flying bombs. It was found that the system used to number the final assemblies was too complicated relative to the size of the sample to yield reliable production estimates. Basically, therefore, the analysis depended on the numbering of main components, such as air grids and the fuel controls. Production figures so derived were consistent with each other and showed a sharply rising trend. This result, however, was inconsistent with the known rate of launchings, and, during the war, satisfactory explanation for this divergence was lacking. Later it was discovered that although the production of components occurred as was indicated by serial number analysis, the assembly of flying bombs did not take place at the same rate. Shortage of sheet metal was a bottleneck which prevented the rate of assembly from equalling component production. Analysis of V-1 markings revealed that the industry had no target potentialities. Production was found to be dispersed among some 50 component makers.

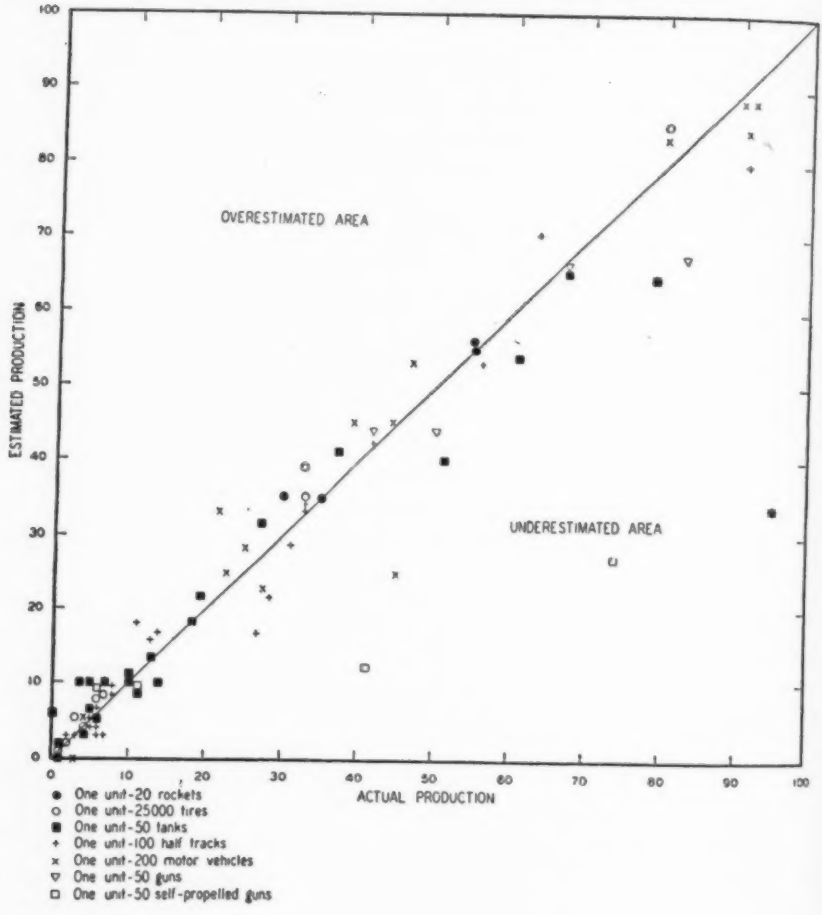
Analysis of rocket (V-2) markings. Estimates of rocket production (V-2) presented fewer difficulties than the V-1 despite the limited number of cases available for examination.[6] Production was numbered in a simple continuous series and the final assembly number was stencilled or stamped on several components. Since no assembly dates were indicated the time of manufacture was placed between the latest date on the component parts and the date the rocket fell. The earliest rocket analysis was based on only seven cases, the most complete study on 25 cases, yet the resultant production estimates later proved to be completely reliable. Estimates of rocket output were made with a time lag of only about two weeks between the issue of the study and the production period covered. While there appeared to be only one assembler of the rocket it could not be identified. As with the V-1, component parts manufacture was found to be unduly dispersed.

[6] The first German V-2 rocket was examined by EWD staff long in advance of the rocket launchings against England. A rocket fell in Sweden and the parts were flown to England for examination. Over 200 sets of markings were found on these pieces and each of these was studied in order to aid in later identification of relevant series to be collected. Manufacturers' identifications were conspicuously lacking on this experimental rocket. However, a very small inspector's stamp indicated that inspector 109 inspected the venturi (the opening for the jet). Files on other types of equipment (filed by inspection numbers) revealed that this same die 109 had been used on certain types of heavy shells. Fortunately the manufacturer had inscribed his code "aux" on these shells. Another file (equipment filed by manufacturer) revealed that "aux" had made a large number of various kinds of ammunition with several other inspection marks. The inspection mark files were again consulted and several of these inspection marks were found to be associated with the symbol "P*" in the period before the coding system came into effect. This symbol "P*" was looked up in the second file again and a group of items were found, some of which were made as early as 1938. At this time this firm was the sole maker of special types of ammunition (they introduced a 2 cm anti-aircraft shell of a special type) and thus was easily identified as Polte in Magdeburg. Thus it was decided that the large venturi of this rocket was produced in this factory. After the war it was verified that they had done this work.

II

In Chart I, the estimates of production of German equipment based on serial number analysis and the comparable official output data ob-

CHART I. A SCATTER DIAGRAM OF THE ACCURACY OF INDIVIDUAL ESTIMATES, BY TYPE AND MODEL AND BY YEAR FOR SEVEN TYPES OF MILITARY EQUIPMENT



tained from the Speer Ministry are given. The estimates and the corresponding data are plotted in a scatter diagram. Correct estimates lie on the 45° line. Only those estimates which are individual and unrelated

to each other have been plotted. Thus yearly estimates by type or model of equipment have been used instead of aggregate figures. This shows the estimates in their most critical light since errors tend to balance out if cumulative aggregates covering long periods of time are used. It will be observed that all estimates in which there were large errors were too low. For more than 90 per cent of the estimates, however, the errors were not sufficiently large to impair the validity of the analysis.

The summary character of Chart I does not fully portray the accuracy of the results achieved by serial number analysis. It is not proposed here to review the accuracy of the estimates in complete detail, but for purposes of clarification some aspects of the estimates are amplified below.

1. *Tires.* The study issued in July, 1944, covered German monthly production of truck, passenger car, and aero tires through the first quarter of 1943. The following table compares the accuracy of these first quarter estimates with Speer Ministry statistics of average monthly production for all of 1943.

Type of Tire	Estimated Average Monthly Production, Jan.–Mar. 1943	Actual Average Monthly Production, 1943[1]	Percentage Error
Truck and Passenger car	147,000	159,700	8% –
Aero	28,500	26,400	8% +
Total	175,500	186,100	6% –

[1] It is quite possible that production of trucks for the first quarter was different than the average for the year. However it is known that production was quite steady throughout 1943, so these official figures serve as an approximation for the first quarter.

The accuracy of the serial number estimates can be better appreciated from the fact that Allied intelligence agencies, by other methods, had placed production at between 900,000 and 1,200,000 tires a month. The significance of the wide disparity in these estimates for purposes of target selection and determination of Germany's overall rubber requirements is obvious. Estimated output of individual producers did not achieve quite the same degree of accuracy as the figures of total production. However, they clearly established the order of importance of individual makers. Individual plant estimates tended to be slightly high. This was probably due to the fact that the serial number

bands of these makers included motor cycle as well as truck, passenger and aero tires.

2. *Motor Vehicles.* The most comprehensive study of German motor vehicle production was issued in April 1944. It included estimates of output by type and maker of trucks and half-tracks from 1940 through 1942. Coverage of half-track production was extended through 1944 in a subsequent report.

(a) *Trucks.* Complete data on German production of all types of trucks were not available for comparison with serial number estimates. Speer Ministry figures were obtained, however, for 1942 output, and these are compared with the estimated figures for the same year in the following table:

Type of Truck	Estimated Production for 1942	Speer Ministry Statistics	Percentage Error
Light truck	16,500	14,436	15%+
Medium truck	62,300	53,439	17%+
Heavy truck	18,500	11,952	35%+
Total	97,300	79,827	22%+

From the above table, trucks appear to be an exception to the general rule that serial number analysis tended to underestimate German production. However, a consistent tendency to overestimate production is not revealed by comparison of a number of individual plant estimates with the production figures shown in individual plant records. In almost all these cases the estimates did not exceed actual production. This suggests the possibility that the Speer figures include only truck production for direct military use. Regardless of whether or not this is the case, however, the estimates for truck production provided at least a good approximation of German output. The previously held opinion of intelligence agencies placed truck production in the neighborhood of 200,000 vehicles per annum. On an individual plant level the estimates, to the extent that they could be checked, showed extreme accuracy in assessing the relative importance of firms and listing the types they made.

(b) *Half-tracks.* A report issued in March 1945 covered German half-track production by type and company from 1941 through 1944. The estimates were quite accurate, as is shown by the following comparison of estimated with actual annual production for the 4 year period:

Year	Estimated Production	Speer Ministry Statistics	Percentage Error
1941	7,850	8,436	7% −
1942	9,500	10,150	6% −
1943	17,000	16,971	2% +
1944	14,500	17,134	15% −
Total	48,900	52,691	7% −

Production estimates by maker and type of vehicle showed almost the same degree of accuracy as the annual totals.

3. *Tanks.* The record of tank serial number estimates is extremely good in comparison with other estimates of tank production made by Allied intelligence agencies. In the table below, estimated average monthly production for 1940–42 based on serial numbers is compared with estimates taken from Munitions Record No. 24, 10 August 1942, and with corresponding figures from the Speer Ministry. The figures given in Munitions Record No. 24 represented the combined views of American and British intelligence agencies at that time.

Date	Estimated Monthly Production		Monthly Production Speer Ministry
	Serial Number Estimate	Munitions Record 10 Aug. 42	
June, 1940	169	1000	122
June, 1941	244	1550	271
August, 1942	327	1550	342

Some indication of the accuracy with which the relative importance of individual makers was assessed is indicated in the following comparison of estimated distribution of Mark V (Panther) production during 1944 compared with actual distribution:

Maker	Estimated	Actual
Maschinenfabrik Augsburg-Nürnberg A.G.	40%	35%
Daimler-Benz A.G.	29%	31%
Maschinenfabrik Niedersachsen-Hanover A.G.	28%	31%
Other	3%	3%

Only in the case of assault guns mounted on tank chassis were serial number estimates wide of the mark. Estimates of 1940 and 1941 assault gun production (*Sturmgeschutz*) erred by −18%. However, the 1942 and 1943 estimates underestimated production by 71% and 62% re-

spectively. These errors were largely due to the fact that collection of markings on this kind of equipment was neglected in the field,[7] so that no cases existed for many types of *Sturmgeschutz*. This situation was never corrected, and greater emphasis continued to be given to tanks.

4. *Guns*. As already pointed out, production estimates were made for only a few types of German guns, and complete official output figures were not available to check on the accuracy of all of these estimates. Estimates of three types of 7.5 cm guns were checked against Speer Ministry statistics. The comparison is as follows:

Type	Year	Estimated Production	Actual Production	Percentage Error
7.5 cm. Pak 40	1942	2200	2112	4% +
7.5 cm. Kwk 40	1944	3300	3360	2% −
7.5 cm. Kwk 42	1944	3350	4210	20% −

The above figures were sufficient to indicate that the serial number technique was applicable to guns.

5. *Flying Bombs and Rockets*. The Speer Ministry statistics on flying bomb (V-1) production were found to be radically inconsistent with even partial reports from the individual assembly plants. As a result no accurate aggregative statistics exist for V-1 production. Documents and interviews, however, revealed that there had been about 12,000 bombs produced by the time the first one was launched against England. The serial number estimate was fairly accurate for this period, since it indicated that 13,000 flying bombs had been produced. The Germans had planned for a peak production of 6000 weapons a month, but it is believed that the rate of completions never exceeded 3000 a month due to lack of sheet metal for final assembly. In other words, actual production in June and July 1944 was probably not in excess of 6000, whereas the serial number estimate for these two months was 18,000. The large error resulted from the fact that there was little correlation between component parts production, on which the estimate was based, and the rate of final assembly. Apparently the original component parts program was in full swing before the sheet metal bottleneck developed. Presumably, after a time, component

[7] In fact, one of the collectors had a reputation for being "Panther-happy." The doubtfulness of the *Sturmgeschuts* estimates was known, and these estimates were in direct contradiction to gun estimates made concurrently. The gun estimates reflected the true level of *Sturmgeschuts* production, but these figures were not adopted.

parts production would have been curtailed and the error in the estimates detected. However, the flying bomb production was too short-lived after this bottleneck developed (about 3 months) for this adjustment to work itself out.

Rocket (V-2) production estimates proved to be more accurate. The following is a comparison of estimated and actual production.

Period of Production	Estimated Production	Actual Production	Percentage Error
Up to 15 Sep. 1944	670 (minimum)	1900	65% −
15 Sep. –29 Oct. 1944	1030	900	14% +
29 Oct. –24 Nov. 1944	700	600	17% +
24 Nov.–15 Jan. 1945	1100	1100	0
15 Jan. –15 Feb. 1945	700	700	0

The first rocket report underestimated total production by 1230. This error was due to the fact that a large number of early experimental rockets were used up in tests, and were never fired on England or Belgium. These experimental models were numbered in a different series from those fired on England and Belgium. That the method of serial number analysis of rockets was correct is apparent from the fact that the estimates for subsequent periods had a maximum error of 17% and twice were completely accurate.

The relative accuracy of the serial number estimates indicates that this method of analysis was a valid and valuable source of economic intelligence. Within the limits of its capabilities, the technique of analyzing markings on enemy equipment was superior to the more abstract methods of intelligence such as reconciling widely divergent prisoner of war reports, basing production estimates on pre-war capabilities or projecting production trends based on estimates of the degree of utilization of resources in the enemy country.

GRANT-IN-AID APPORTIONMENT FORMULAS

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This paper presents the characteristics of the more important types of apportionment formulas. From the standpoint of effects of grants upon program or service aided, formulas are examined with reference to two criteria or conditions. A form of algebraic examination of formulas is presented which permits determination of characteristics of apportionment methods without numerical computations. This is done in terms of amount of grant, amount of local contribution, total program supported, rate of local effort, and relationship between central and local funds.

ALONG with tax-sharing and similar devices, the grant-in-aid is one of the important means of adjusting revenue resources and spending functions among levels of government.[1] All grants may be examined from the standpoint of their contribution to the problem of fiscal adjustment. Though a central government may have to aid subdivisions in the financial support of their programs of education, highway construction, public assistance, or health, partly because it has the revenue resources and the subdivisions do not, the test of a grant might most appropriately be in terms of what it does for the program or service aided.

Many faults in the design of formulas now in use and of those recently proposed are due in large part to failure to identify clearly the objectives of the grant, or to recognize in the apportionment scheme itself the extent to which it accomplishes its objectives.

It is the purpose of this paper to present the characteristics of the more important types of apportionment formulas. Each is now in use, either as a Federal or a State statutory or administrative formula, or has been seriously considered by policy forming groups or legislative bodies.

It is to be noted that actual plans are often hybrids of these types.

[1] For a recent comprehensive discussion of this, see Senate Document 69, 78th Congress, 1st Session, *Federal, State, and Local Government Fiscal Relations*, a Report of the Treasury Committee on Intergovernmental Fiscal Relations. General treatments on grants-in-aid are: Bitterman, Henry J. *State and Federal Grants-In-Aid.* New York: Mentzer, Bush and Company, 1938, 544 p.; Key, V. O. Jr. *The Administration of Federal Grants to States.* Chicago: Public Administration Service, 1937, 383 p. See also Maxwell, James A. *The Fiscal Impact of Federalism in the United States.* Cambridge: Harvard University Press, 1946, 427 p. The approach of this paper is generalised. That is to say, it is applicable to Federal or to State grants. The terms "central" and "local subdivision" might, therefore, represent respectively Federal and State, or State and country or municipality.

Omitted from this discussion are fixed sum grants, e.g., $50,000 to each State for land-grant colleges,[2] and grants distributed according to fiscal capacity. The latter are forms of tax-sharing rather than program subvention.

The formulas in this analysis will be examined in terms of two criteria or conditions. It is assumed that a system of central sharing of costs of locally administered services should satisfy:

Condition (a): A standard minimum level of expenditure, u, per unit of service is assured through the combined support of the central and local governments.

Condition (b): A uniform effort (ratio of revenues to resources) of local units to provide local contributions to the support of the standard minimum program.

It is further assumed that the standard minimum is an adequate one and that additional local effort may be exercised beyond that required in condition (*b*).

In practice, objectives of grants may be (a) obscure, (b) combinations of several purposes, e.g., compromises satisfying the aims of different pressure groups, or (c) incidental to the effective advancement of the program aided. For convenience of analysis, considering grants as devices primarily for the purpose of financing a service, they may be classified as:

i. *Straight grant*—purpose of central government financially to underwrite local programs. Sometimes called *unconditional grant.*

ii. *Stimulation grant*—purpose of central government to stimulate or induce local authorities to undertake new services, or to maintain and improve existing ones. Sometimes called *conditional* grant.

STRAIGHT GRANTS

The feature of what is called here the straight grant is the absence of conditions upon the local subdivision on how much money it is to raise through its own resources, and consequently upon its local expenditures. Local rates of effort are used solely as a basis of determining the amount of the central allotment. This type of grant is important in such services as education where central financial assistance is required, but local control, and particularly local control over powers of raising revenues, is to be retained in local subdivisions of government.

The ideal model for central sharing of costs of governmental subdivisions is the equalization formula used by many States. The equalization plan satisfies both of the two conditions.

[2] Nelson Amendment of March 4, 1907, 34 Stat. L. 1281.

The actual pattern of financial support of public education in the State of Maryland illustrates a close approximation to this type. In Table 1 are approximate school expenditures for five Maryland counties arranged in order of fiscal capacity to support schools. Baltimore county is the highest in assessed valuation per pupil ($13,610). Charles county is the lowest in assessed valuation per pupil ($3,339). Condition (a) tends to be satisfied since the total program shows evidence of a minimum level of expenditure of about $2,000 per classroom unit. County expenditures tend to vary in direct proportion to fiscal capacity. Hence the State of Maryland's pattern of school financial support roughly satisfies condition (b).

TABLE 1

CENTRAL AND LOCAL FINANCIAL SUPPORT OF EDUCATION, SELECTED COUNTIES, STATE OF MARYLAND*

County	Annual expenditures per classroom unit, 1944		
	County sources (local)	State sources (central)	Total
Baltimore	$1,517	$ 846	$2,363
Queen Ann's	1,115	1,253	2,368
Carroll	964	1,314	2,278
St. Mary's	555	1,462	2,017
Charles	403	1,825	2,228

* From State of Maryland, Department of Education. *Seventy-Eight's Annual Report*, Year Ending June 30, 1944. State sources included Federal grants.

A recent proposal for Federal grants to States for education is of this type. Amounts of aid per pupil to each of five States under this proposal are given in Table 2.[3]

The Equalization Model

Under the equalization model the amount of central grant, A_i, to the ith local governmental subdivision is

$$A_i = uN_i - rC_i \tag{1}$$

where u is the standard unit cost, e.g., expenditure per pupil, r the uniform rate of local effort, N_i is the number of program units in the ith governmental subdivision, and C_i is some measure of fiscal capacity in the ith governmental subdivision. The total cost of the program supported is uN_i. The local contribution is rC_i.

[3] The five States are arranged in order of per capita income payments for 1945: New York, $1,600; Illinois, $1,400; Montana, $1,200; West Virginia, $800; Mississippi, $550. From *Survey of Current Business*, October 1946, p. 16.

TABLE 2

CENTRAL AND LOCAL CONTRIBUTIONS, SELECTED STATES, EDUCATIONAL FINANCE ACT OF 1946, (S.181)*

State	Annual expenditures per child		
	State sources (local)	Federal aid (central)	Total
New York	$40	$ 0	$40
Illinois	40	0	40
Montana	39	1	40
West Virginia	21	19	40
Mississippi	13	27	40

* From U. S. Senate Committee on Education and Labor. *Federal Assistance to the States for the Purpose of More Nearly Equalizing Educational Opportunities.* Report No. 1497, 79th Cong., 2nd Session.

The annual grants to States under the proposed Educational Finance Act of 1946, as shown in Table 2, were based upon

u = \$40

r = .011

N_i = population 5–17 years of age in ith State

C_i = annual income payments (five-year average) in ith State.

The amounts shown in the first column of Table 2 are equivalent to rC_i/N_i. The Federal aid shown in the second column of the table is equivalent to $A_i/N_i = u - rC_i/N_i$. Tabular analysis is facilitated by computations made on a *unit* basis.

There are many variations of applications of the above model. Sometimes uN_i is determined administratively through "approved budgets." In computing uN_i there may be allowances for differences in cost, u, among localities. This is usually done by making N_i a function of several factors, $f(x_i, y_i, \ldots)$, such as population density and cost-of-living.

Many alternatives are available in defining C_i. In States it is usually property valuations of local units. Recent proposals for Federal grants to States have used income payments as the measure of fiscal capacity of States. This paper assumes some satisfactory measurement of need, N_i, and fiscal capacity, C_i.

The values assigned u and r determine the pattern of apportionment. They are usually somewhat arbitrarily determined. Sometimes u is set as the average expenditure per unit. That is frequently done in education. However, average practice, particularly in newer services, is not a valid criterion of the level of expenditure to be supported. It is often

that level which the particular amount of central appropriation makes possible with the apportionment scheme used.

Ideally, r is the rate necessary to yield all of the standard program in the first local subdivision, the one with highest fiscal capacity per unit of need, that is:

$$r = \frac{uN_1}{C_1}.$$

In practice r is sometimes set high enough to exclude several of the abler subdivisions. (See, for example, plan in Table 2.)

The Flat Grant

If r is set low enough to permit the first and ablest subdivision to receive aid, part of the aid to each subdivision is flat grant, i.e., a fixed amount u' per unit of need N_i. This will occur for any $r < uN_1/C_1$. If in the application of Formula (1) no local contribution is considered in computing central aid, i.e., $r = 0$, then the entire grant is flat grant, and

$$A_i = u'N_i \tag{2}$$

when $0 < r < uN_1/C_1$, there are in effect two unit programs, u'', on a strict equalization basis, for which the ablest subdivision receives no central aid, and u' which all districts receive on a flat basis. Formula (1) is thus modified, since

$$u'' = rC_1/N_1, \quad \text{and} \quad u' = u - u'',$$

and becomes

$$A_i = (u''N_i - rC_i) + u'N_i. \tag{3}$$

The Equalized Apportionment

Another type of formula in the equalization category has been used administratively for apportioning funds under the Social Security Act.[4] It does not completely satisfy the conditions given above for strict equalization, but is useful in apportioning funds when total programs, uN_i, cannot easily be determined, and when, nevertheless, it is desired to graduate amounts of aid per unit inversely in proportion to relative fiscal capacity. This may take the form:

$$A_i = uN_i\left(\frac{\sum C_i}{\sum N_i} \times \frac{N_i}{C_i}\right) \tag{4}$$

[4] Public health and maternal-and-child-health provisions. See Key, *op. cit.*, pp. 332–33. The National School Lunch Act (see Table 6) is an interesting example of equalized apportionment. The plan, however, combines equalized apportionment with partially equalized matching. It is thus a stimulation type of grant.

where summations are over all subdivisions, or

$$A_i = uN_i\left(\frac{I_n}{I_c}\right) \tag{5}$$

where $$I_n = \frac{N_i}{\sum N_i} \quad \text{and} \quad I_c = \frac{C_i}{\sum C_i}.$$

An equalized apportionment would result from adapting the equalization model (1). The result would satisfy conditions (*a*) and (*b*). This would take the form:

$$A_i = uN_i\left(\frac{I_n - \bar{p}I_c}{I_n}\right) \tag{6}$$

where $\bar{p} = r\sum C_i / u\sum N_i$, the average ratio of local contribution to total program for all subdivisions. Formula (6) is derived as follows from formula (1):

where $$r = \bar{p}\frac{u\sum N_i}{\sum C_i},$$

$$A_i = uN_i - \bar{p}\frac{u\sum N_i}{\sum C_i}C_i$$

$$= uN_i - \bar{p}uN_i\frac{\sum N_i}{N_i}\cdot\frac{C_i}{\sum C_i}$$

$$= uN_i - \frac{\bar{p}uN_iI_c}{I_n}$$

$$= uN_i\left(1 - \frac{\bar{p}I_c}{I_n}\right).$$

A further modification of the equalization model is identically equal to formula (6), but utilizes an *apportionment index*.

Multiplying equation (6) by $\frac{I_n\sum N_i}{N_i}$ yields the following:

$$A_i = u\sum N_i(I_n - \bar{p}I_c). \tag{7}$$

The index, $I_a = I_n - \bar{p}I_c$, shows the proportionate amount of the total cost of the entire minimum program, $u\sum N_i$, to be granted as central

aid to the individual subdivision. This form has been used in several proposals for Federal aid to education.[5]

The use of formulas (6) and (7) would produce "equalized apportionment," through the equalization pattern satisfying both condition (*a*) and condition (*b*).

STIMULATION GRANTS

Described below are five types of stimulation grant. The first two are the common "matched flat grant" and the "percentage grant." The last three are recent developments meeting the conditions of equalization not met by the other two. All stimulation grants have one thing in common, the amount of aid, A_i, is conditioned by the amount actually raised locally, L_i. The following additional notation is required:

p_i = proportion of program cost from local resources, $L_i/(A_i+L_i)$ in ith subdivision; when constant $= p$.

v_i = ratio of local to central support $= p_i/(1-p_i) = L_i/A_i$; when constant $= v$.

$\bar{v}$ = average ratio of local to central support summed over all subdivisions, $\sum L_i/\sum A_i$.

$1/v_i$ = ratio of central to local support.

In Table 3 are shown values and relationships necessary for identifying and appraising the five stimulation types of grant. The basic forms of these types are discussed in some detail, since the stimulation feature is one easily leading to violation of the two criteria given above. Only recently has serious thought been given to remedying the defects of the stimulation grant, even though it has become the chief method of apportioning Federal grants to States.[6]

The Matched Flat Grant

This is characterized by Federal grants-in-aid for education and highways. Allotments are made to States on the basis of population or some other measure of need. States to receive the full amount must match

[5] See The Advisory Committee on Education, *Principles and Methods of Distribution of Federal Aid for Education*, Staff Study No. 5. Washington: U. S. Government Printing Office, 1939, p. 82 ff. For recent bill see S.181, 79th Congress, 1st Session. In addition to the advantage of convenience in apportionment when amounts of the central appropriation cannot be determined in advance, there is an advantage of stability in using the equalization model in index form. See F. G. Cornell, "To Stabilize State School Support," *Nation's Schools*, 21: 31–33, May 1938.

[6] The Social Security Board has been active in this direction. See Daniel S. Gerig, Jr., "The Financial Participation of the Federal Government in State Welfare Programs," *Social Security Bulletin*, January 1940, and "Formulas for Variable Federal Grants-in-Aid," *Social Security Bulletin*, June 1940. See also *Issues in Social Security: A Report of the House Committee on Ways and Means by the Committee's Social Security Technical Staff*, 1946 (79th Cong., 1st Sess.), and H.R. 6911, (79th Cong., 2nd Sess.).

TABLE 3

ANALYSIS OF FIVE TYPES OF STIMULATION GRANT

Type of formula	Amount of central grant (A_i)	Local contribution required to receive full aid (L_i)	Total program supported (A_i+L_i)	Rate of local effort (r_i)	Ratio usually used in fixing relationship of A_i and L_i
(1)	(2)	(3)	(4)	(5)	(6)
Type A.—Matched flat grant	$\frac{L_i}{p} - L_i \leq uN_i$	$v(uN_i)$	$\frac{L_i}{p} \leq \frac{uN_i}{1-p}$	vuN_i/C_i* (variable)	$v = L_i/A_i$ (constant)
Type B.—Percentage grant	$\frac{L_i}{p} - L_i$	None	L_i/p	L_i/C_i (variable)	$\frac{1}{v} = \frac{A_i}{L_i} = \frac{1-p}{p}$ (constant)
Type C.—Flat grant with equalised matching	$L_i\left(\frac{I_n}{\bar{v}I_c}\right) \leq uN_i$	$\frac{I_c}{\bar{v}} - (uN_i)\frac{I_c}{I_n}$	$L_i\left(1+\frac{I_n}{\bar{v}I_c}\right) \leq uN_i\left(1+\bar{v}\frac{I_c}{I_n}\right)$	Constant $\left(\frac{u\Sigma N_i}{\Sigma C_i}\right)\bar{v}$*	$v_i = L_i/A_i = \bar{v}\frac{I_c}{I_n}$ (variable)
Type D.—Matched equalisation grant	$\frac{L_i}{p_i} - L_i \leq uN_i - rC_i = uN_i - \bar{p}\frac{I_c}{I_n} = uN_i(1-p_i)$	rC_i	$\frac{L_i}{p_i} \leq uN_i$	Constant, r*	$p_i = L_i/A_i + L_i = \frac{rC_i}{uN_i}\frac{I_c}{I_n} = \bar{p}\frac{I_c}{I_n}$ (variable)
Type E.—Equalised percentage grant	$L_i\left(\frac{uN_i}{rC_i}-1\right) = L_i\left(\frac{I_n}{\bar{p}I_c}-1\right)$	None	$\frac{L_i}{rC_i} \leq uN_i$	Constant, r†	$\frac{1}{v_i} = \frac{A_i}{L_i} = \frac{uN_i}{rC_i}\frac{I_n}{\bar{p}I_c} - 1 = \frac{uN_i}{rC_i} - 1$ (variable)

* Rate required to receive full aid.
† Rate required to receive normal aid, $uN_i - rC_i$.

with State and local funds at a fixed rate, v, per dollar of Federal allotment (Table 3, col. 6). The matched grant stimulates through the negative inducement of penalizing the recipient subdivision by reducing its grant in proportion as its matching is below the requirement $v(uN_i)$, (col. 3).

This type meets condition (a) of uniform program. If all subdivisions match fully, the standard program per unit of service is $u/(1-p)$, (col. 4). The rate of local contribution is variable (col. 5), and is greatest in subdivisions with low fiscal capacity in proportion to need (since $r_i=vuN_i/C_i$). It, therefore, is directly contrary to condition (b). The division of central and local contribution is constant (col. 6). An example of this type is given in Table 4.

The Percentage Grant

This type of grant has long been used in England and was introduced into Federal-aid legislation by the Social Security Act of 1935 (See Table 5). It is based upon expenditures in the local subdivision. It is similar to the matched grant but has no cut-off or maximum by allotment on a uN_i basis. The amount of aid, A_i, is directly related, therefore, to the local contribution L_i. This is often called "reward for efforts" aid. It is a pure stimulation type. The ratio of central cost to local cost, $1/v$, is a predetermined constant. The formula is of the form

$$A_i = \frac{1-p}{p} L_i = L_i/p - L_i. \tag{8}$$

It violates condition (a), as the total program supported, L_i/p, is directly related to local revenues (Table 3, col. 4). These in turn tend to be related to fiscal capacity. In this respect its effects are just the opposite of equalization (Table 5). Insofar as local subdivisions are not compelled to tax themselves at effort above average, though they may choose to do so to receive more aid, this type satisfies condition (b). As in the case of the matched grant, the proportionate division of central and local contributions is constant (col. 6).

The Flat Grant with Equalized Matching

This modification of the matched grant has been discussed for purposes of Federal legislation.[7] It produces an unequalized program (col. 4) with equal effort of local contribution (col. 5), thus satisfying con-

[7] Federal Aid for School Lunches, S.503, 79th Congress, 1st Session. This was revised in S.962, 79th Congress, 1st Session, to a form of "equalized apportionment" (see table 6), with "equalized matching" for States below average per capita income.

dition (*b*), but not condition (*a*). The combined central and local support (col. 4) yields funds per unit of need, N_i, directly related to the ratio I_c/I_n. Hence, ablest subdivisions financially have most funds. Un-

TABLE 4

STATE AND FEDERAL EXPENDITURES FOR AGRICULTURAL EDUCATION, SELECTED STATES, GEORGE-DEEN ACT*

State	Annual expenditures per farm child		
	State sources (local)	Federal aid (central)	Total
New York	$.123	$.123	$.246
Illinois	.123	.123	.246
Montana	.123	.123	.246
West Virginia	.123	.123	.246
Mississippi	.123	.123	.246

* Computed from tables of allotments in U. S. Office of Education, *Digest of Annual Reports of State Boards for Vocational Education*, Fiscal Year Ended June 30, 1944. See P. L. 673, 74th Cong.

TABLE 5

APPROXIMATE STATE AND FEDERAL CONTRIBUTIONS TO ASSISTANCE PAYMENTS TO THE AGED, SELECTED STATES, SOCIAL SECURITY ACT*

	Monthly payments per recipient		
	State sources (local)	Federal aid (central)	Total
New York	$18.80	$18.80	$37.60
Illinois	16.99	16.99	33.98
Montana	16.32	16.32	32.63
West Virginia	8.61	8.61	17.22
Mississippi	8.31	8.31	16.62

* Approximate amounts based on average payments to recipients as of June 1946. *Social Security Bulletin*, August 1946, p. 45. An additional Federal grant amounting to $5 per recipient to be provided during 15-month period, October 1, 1946, to December 31, 1947, by amendment to Social Security Act. See H.R. 7037, 79th Cong., 2nd Session.

like the first two types of stimulation grant, the proportionate division between central and local contributions in this type is variable (col. 6).

A device to overcome the shortcomings of this type is exemplified in Table 6 by the National School Lunch Act as finally enacted. This is done by using equalized apportionment in place of the flat grant in combination with equalized matching.

Matched Equalization Grant

This type of stimulation grant is based directly upon the equalization

model given above, formula (1).[8] As a matter of fact, it is identical to it with the added requirement that the local subdivision *must* put up its local contribution, rC_i (col. 3). In proportion as it fails to produce this local contribution, in that proportion its aid is reduced. Except for such reductions due to the "matching" penalty, the type satisfies both conditions (*a*) and (*b*). The division of cost between central and local governments is variable (col. 6). The proportionate local component varies directly as relative fiscal capacity (I_c/I_n).

Equalized Percentage Grant

A further adaptation of the equalization model is similar to the matched equalization grant.[9] The only difference lies in the fact that it

TABLE 6

APPROXIMATE STATE AND FEDERAL CONTRIBUTIONS FOR SCHOOL LUNCH PROGRAM, SELECTED STATES, NATIONAL SCHOOL LUNCH ACT*

State	Annual expenditure per child		
	State sources (local)	Federal aid (central)	Total
New York	$1.28	$1.28	$2.56
Illinois	1.48	1.48	2.96
Montana	1.73	1.75	3.48
West Virginia	1.73	2.45	4.18
Mississippi	1.73	3.67	5.40

* From *Social Security Bulletin*, August 1946, p. 54. See P.L. 396, 79th Cong., 2nd Session.

is an "open end" grant, typical of percentage grants. Aid to any subdivision increases with local expenditure. A variable rate of central to local matching

$$\frac{uN_i}{rC_i} - 1, \quad \text{(col. 6)},$$

is the key to this type. This matching rate applied to L_i determines A_i, (col. 2). This varies from strict equalization only to the extent that $L_i \neq rC_i$.

[8] Gerig identifies four practical variations of what he terms variable matching: (a) "linear interpolation," (b) "bracket type," (c) "ratio to midpoint," and (d) "ratio to average," *op. cit.* For draft of "bracket type" see H.R. 4499, 79th Congress, 1st Session, which would apportion Federal funds to States for educational plant facilities. For three variations of this type in pure form see Byron L. Johnson, "Intrastate Equalization in Financing Public Assistance," *Social Security Bulletin*, June 1945.

[9] This plan is advocated by Lindman for Federal aid to education. See Erick L. Lindman. "Equalization of School Support Among States by Federal Matching," *Journal of Educational Research*, 37: 580–95, April 1945.

FOUR HYPOTHETICAL APPORTIONMENT PLANS - Showing Combined Central and Local Expenditures For Unit of Service, Subdivisions Arranged in Order of Fiscal Ability Per Unit

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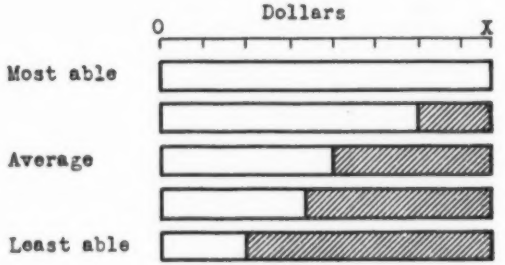

Chart 1.
EQUALIZATION MODEL - Expenditure and local effort equalized.

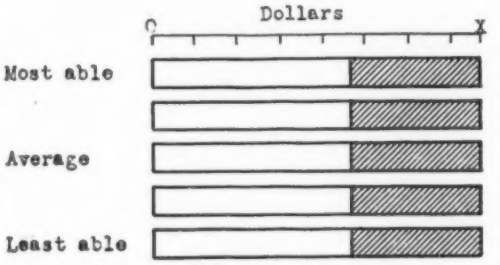

Chart 2.
MATCHED FLAT GRANT - Only expenditure equalized - unequal local effort.

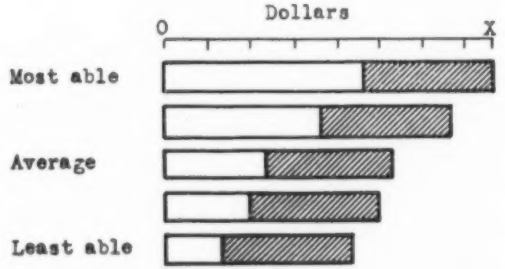

Chart 3.
FLAT GRANT WITH EQUALIZED MATCHING — Equal effort - unequal expenditure.

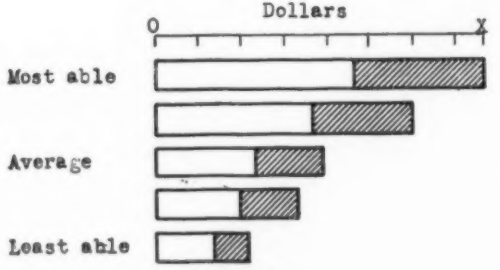

Chart 4.
PERCENTAGE GRANT - Expenditure not equalized at equal or at unequal local effort

Local Contribution Central Grant

SUMMARY

Two criteria may be applied to proposed grant-in-aid apportionment formulas. One of these is the criterion of equality of standard minimum of service and the other is the criterion of equality of local effort. According to the former, combined central and local financing should provide a uniform minimum expenditure per unit of service. According to the latter, local contributions should be expected to be in proportion to ability or fiscal capacity.

An algebraic examination of formulas permits determination of the behavior of apportionment schemes with reference to these criteria. An analysis in terms of amount of grant, amount of local contribution, total program supported, rate of local effort, and relationship between central and local funds reveals the features of the major types of apportionment formula of current interest. Chart 1 represents the equalization model which meets the conditions set by both criteria. Two recent grant types, the matched equalization grant and the equalized percentage grant, are adaptations of the equalization model (chart 1) developed to remedy defects of conventional forms of the matched grant (chart 2) and the percentage grant (chart 4). A proposal to apportion flat grants with equalized matching (chart 3), though an improvement upon the matched flat grant (chart 2), does not satisfactorily compare with the equalization model (chart 1).

METHODS OF MEASURING THE MARGINAL PROPENSITY TO CONSUME[1]

TRYGVE HAAVELMO
University of Chicago

This study deals with statistical principles and methods of deriving estimates of the marginal propensity to consume, from time series of total consumption, income, and investment.

It is shown that the method of obtaining the marginal propensity to consume by correlating consumers' expenditure with income is inconsistent with an important branch of current economic theory: the method tends to overestimate the marginal propensity to consume. If, as in some important modern economic theories, investment is regarded as an independent, autonomous variable, the corresponding correct statistical procedure is, first, to obtain the "multiplier" by correlating income with investment, and then, from this estimate of the multiplier, to calculate the marginal propensity to consume. (These results follow from the general principles of the "Simultaneous-Equations Approach," as developed by the Cowles Commission for Research in Economics.)

Some theoretical results are given also for the alternative case where investment is, in part, induced by changes in income.

Numerical illustrations show the results of applying the theoretical formulae to U. S. statistics of consumption, income, and investment, for the interwar period.

1. INTRODUCTION

THE marginal propensity to consume and its companion, the multiplier, are of central importance in modern theories of macroeconomics. The intense interest in these parameters derives largely from the importance that modern theories (and many older ones too) attach to the rate of investment as a primary factor in determining the levels of income and employment. In some theories investment is considered as an autonomous variable, an impressed force. (E.g. Schumpeter's theory of innovations.) Other theories, while operating with the notion of induced investment, imply, nevertheless, that current investment is, in part at least, an autonomous variable, its main determinants being such "external" factors as growth of population, new

[1] Cowles Commission Papers, New Series, No. 22. Some of the methods discussed below were developed in connection with a study of the demand for agricultural products, now in progress at the Department of Economics, The University of Chicago. The author is indebted to his colleagues at the Cowles Commission for many helpful suggestions.

inventions, wars, etc., or *past* values of some other economic variables, such as profit, sales, or capital accumulation. It is in line with these ideas that attempts to derive, statistically, the marginal "propensity to invest" apparently have met with little success. The current view on the subject is probably well expressed in the following statement by Alvin H. Hansen: "Thus, the statistical data during the last two decades tend to support the thesis that the active dynamic factor in the cycle is investment, with consumption assuming a passive, lagging role."[2] Qualifying this statement somewhat, he continues: "For the most part, spontaneous expenditures—expenditures not caused by a prior rise in income—are likely to be made on investment goods or upon durable consumers' goods, but not upon other forms of consumption.

"It does not follow, however, that all investment is spontaneous. Much of it is, in fact, induced. It is, however, quite impossible to determine statistically what part is spontaneous and what part is induced."[3] Many economists would agree with Paul A. Samuelson's statement that "In behavior it [i.e., investment][4] is sporadic, volatile, and capricious. Its effective determinants are almost completely independent of current statistical factors (level of income, etc.)."[5]

If this is the current view on the role of investment, it is somewhat surprising to find that current attempts to derive, statistically, the marginal propensity to consume approach the problem by correlating consumers' expenditures with income.[6] This procedure is inconsistent with the view that investment is the autonomous determinant of income. We should, instead, take the regression of income *on investment*, to obtain the multiplier, and from this estimate of the multiplier we should derive the marginal propensity to consume. This idea, I am sure, is not new, but it might perhaps be useful to set down the arguments involved in somewhat more rigorous terms. I shall also give some numerical results, as illustrations.

2. ESTIMATION OF THE CONSUMPTION FUNCTION WHEN INVESTMENT IS AN AUTONOMOUS VARIABLE

In this Section we shall be concerned with the following observable time series:

[2] Alvin H. Hansen, *Fiscal Policy and Business Cycles*, New York, 1941, p. 50.
[3] *Op. cit.*, pp. 62–63.
[4] Author's remark.
[5] Paul A. Samuelson: "Full Employment After the War," in *Postwar Economic Problems*, edited by S. E. Harris, New York, 1943, p. 41.
[6] See, for example, Arthur Smithies, "Forecasting Postwar Demand: I," *Econometrica*, Vol. 13, 1945. No. 1, pp. 4–6, Jacob L. Mosak, "Forecasting Postwar Demand: III," *Econometrica*, Vol. 13, 1945, No. 1, p. 44, and others, too numerous to be mentioned here.

c_t = consumers' expenditure, in constant dollars per capita,
y_t = disposable income, in constant dollars per capita,
z_t = investment expenditures, in constant dollars per capita.

The term investment, as used here, is defined as the difference between disposable income and consumers' expenditure. (In terms of current statistical measurements by the U. S. Department of Commerce investment, as defined here, would be equal to private net investment minus corporate savings plus Government deficits. Cf. Section 4 below.) This means that we impose the exact relationship

$$y_t = c_t + z_t. \tag{2.1}$$

We assume further that the consumption function is a linear function of disposable income, but that this function is subject to random shifts. Let this function be

$$c_t = \alpha y_t + \beta + u_t \tag{2.2}$$

where α and β are constants, and u_t is the random element in consumers' behavior. The problem is to estimate the true values of α and β, by means of a certain number of observations of the time series c_t, y_t, and z_t. The u's are not observable.

The model, as it stands, is not complete. It does not determine the levels of income, consumption, and investment, even if we knew the true values of α and β. There are three variables, y, c, z, and only two equations, (2.1) and (2.2). For the same reason the model does not as yet tell us how to proceed statistically in order to estimate α and β. The model, as it stands, does not determine how the joint probability distribution of the observable variables c_t and y_t depends on α and β, and, therefore, does not determine the appropriate type of estimation formulae to be used. It is necessary to complete the model in such a way that the problem of estimating α and β becomes a well-defined statistical problem. For this purpose we add the following assumptions:

a) The random variable u_t has expected value $E(u_t)=0$, and variance $E(u_t^2)=\sigma_u^2$ for every value of t. The u's are serially uncorrelated, i.e. $E(u_t u_{t-\tau})=0$ for $\tau \neq 0$.

b) The time series z_t, $t=1, 2, \cdots$, is autonomous in relation to c_t and y_t. This condition is fulfilled if either

b.1) the sequence z_t is a sequence of given numbers, in which case automatically $E(z_t u_t)=z_t E(u_t)=0$ (by a), or if

b.2) each z_t is a random variable which is stochastically independent of u_t.

If the assumption b.1) is adopted we shall impose the condition that

$$\lim_{N\to\infty} m_{zz} \equiv \lim_{N\to\infty} \frac{1}{N}\sum_{t=1}^{t=N}\left(z_t - \frac{1}{N}\sum_{t=1}^{t=N} z_t\right)^2 = \bar{m}_{zz}, \tag{2.3}$$

where $\bar{m}_{zz}$ is a positive, finite number. Therefore

$$Nm_{zz} \to \infty \quad \text{as} \quad N \to \infty. \tag{2.4}$$

Similarly, if the assumption b.2) is adopted, we shall assume that

$$\operatorname{plim}_{N\to\infty} \frac{1}{N}\sum_{t=1}^{t=N}\left(z_t - \frac{1}{N}\sum_{t=1}^{t=N} z_t\right)^2 = \bar{m}_{zz} \tag{2.5}$$

where $\bar{m}_{zz}$ is positive and finite.[7] These assumptions are used in the analysis of the large-sample properties of the estimates discussed below.

Let us assume that the conditions a) and b.1) are fulfilled. And consider any one of the following two relations derived from (2.1) and (2.2),

$$c_t = \frac{\alpha}{1-\alpha} z_t + \frac{\beta}{1-\alpha} + \frac{u_t}{1-\alpha} \tag{2.6}$$

$$y_t = \frac{1}{1-\alpha} z_t + \frac{\beta}{1-\alpha} + \frac{u_t}{1-\alpha}. \tag{2.7}$$

Under the assumptions made, each of these two equations satisfies the conditions of the Markoff theorem on least squares, when z_t is considered as the independent variable.[8] In the following we shall use the moment notations

$$m_{pq} = \frac{1}{N}\sum_{t=1}^{t=N}\left(p_t - \frac{1}{N}\sum_{t=1}^{t=N} p_t\right)\left(q_t - \frac{1}{N}\sum_{t=1}^{t=N} q_t\right) \tag{2.8}$$

$$m_p = \frac{1}{N}\sum_{t=1}^{t=N} p_t. \tag{2.9}$$

Using well-known formulae from ordinary regression theory, and writing b. u. est. as an abbreviation for "best unbiased estimate,"[9] we can then make the following statements.

[7] "plim" means "the probability limit of". A statistic T_N, say, calculated from a sample of N observations, is said to have the probability limit A if the probability of $|T_N - A| > \epsilon$ approaches zero when N approaches infinity, for every fixed value of $\epsilon > 0$. A statistic T_N having this property is said to be a *consistent* estimate of A, or, to converge stochastically to A.

[8] See, e.g., F. N. David and J. Neyman, "Extension of the Markoff theorem on least squares," *Statistical Research Memoirs, II*, London, 1938, pp. 105–116.

[9] An estimate is said to be unbiased if its expected value is equal to the true parameter. An estimate is said to be a "best unbiased" estimate if its variance is smaller than that of any other unbiased estimate that is linear in the random variables involved.

$$\frac{m_{cz}}{m_{zz}} = \text{b.u. est. of } \frac{\alpha}{1-\alpha} \tag{2.10}$$

$$\frac{m_{yz}}{m_{zz}} = \text{b.u. est. of } \frac{1}{1-\alpha} \tag{2.11}$$

$$\frac{m_{zz}m_c - m_{cz}m_{zi}}{m_{zz}} = \text{b.u. est. of } \frac{\beta}{1-\alpha}. \tag{2.12}$$

We also have

$$s^2 = \frac{N}{N-2}\ \frac{m_{yy}m_{zz} - m^2_{yz}}{m_{zz}} = \text{an unbiassed estimate of } \frac{\sigma_u^2}{(1-\alpha)^2}. \tag{2.13}$$

Under the assumption (2.3) these estimates are *consistent*, that is, any one of the estimates (2.10)–(2.13) has the property that the probability of the estimate deviating more than an arbitrary ϵ from the true parameter approaches zero as N approaches infinity. Since α and β are continuous functions of $1/(1-\alpha)$ and $\beta/(1-\alpha)$ when $\alpha \neq 1$, we also know that the estimates, $\hat{\alpha}$ and $\hat{\beta}$, of α and β, derived[10] from (2.10) or (2.11), and (2.12), will have the following properties.

$$\hat{\alpha} = \frac{m_{cz}}{m_{yz}} = \text{cons. est. of } \alpha \tag{2.14}$$

$$\hat{\beta} = \frac{m_{yz}m_c - m_{cz}m_y}{m_{yz}} = \text{cons. est. of } \beta. \tag{2.15}$$

The "estimates" of α and β obtained by the commonly used procedure of taking the least squares regression of c_t on y_t do not possess this property. Let us denote these "estimates" by a and b, respectively. Then we have

$$a = \frac{m_{cy}}{m_{yy}} \tag{2.16}$$

[10] In the present model, as well as in the model discussed in Section 4 below, the problem of obtaining estimates of the structural coefficients α and β from the regression coefficients in (2.10), or (2.11) and (2.12) happens to be particularly simple, because we have exactly two independent equations defining the estimates of α and β, namely (2.10) and (2.12), or (2.11) and (2.12). [(2.10) and (2.11) give identical estimates of α]. In more general systems of structural equations the situation may be much more complicated: There may be more independent equations of the type (2.11)–(2.12) than there are structural parameters, or there might be too few such equations (as, e.g., in Section 3 below, if q_t is not observable). In such cases different, and—in general—much more laborious estimation procedures are required. For further discussion on this point see, e.g., Tjalling Koopmans, "Statistical Estimation of Simultaneous Economic Relations," *Journal of the American Statistical Association*, Vol. 40, 1945, pp. 458–459.

$$b = \frac{m_{yy}m_c - m_{cy}m_y}{m_{yy}} . \tag{2.17}$$

These "estimates" a and b are not consistent estimates of α and β. This is seen as follows. Using (2.1) and (2.2) we obtain

$$a = \frac{\alpha m_{zz} + (1+\alpha)m_{zu} + m_{uu}}{m_{zz} + 2m_{zu} + m_{uu}} . \tag{2.18}$$

From our assumptions it follows that $m_{zu} \to 0$ and $m_{uu} \to \sigma_u^2$ as $N \to \infty$. Thus, for sufficiently large samples, the statistic a approaches, stochastically, the limit

$$\operatorname*{plim}_{N\to\infty} a = \frac{\alpha + \dfrac{\sigma_u^2}{\bar{m}_{zz}}}{1 + \dfrac{\sigma_u^2}{\bar{m}_{zz}}} > \alpha \quad \text{when} \quad 0 < \alpha < 1. \tag{2.19}$$

Similarly, b will approach the limit

$$\operatorname*{plim}_{N\to\infty} b = \frac{\beta - \dfrac{\sigma_u^2}{\bar{m}_{zz}} m_z}{1 + \dfrac{\sigma_u^2}{\bar{m}_{zz}}} < \beta \quad \text{when} \quad m_z > -\beta. \tag{2.20}$$

Suppose now that we substitute assumption b.2) for b.1), letting the z's be random variables in repeated samples. Then the exact conditions of the Markoff theorem are no longer fulfilled. But under the assumption (2.5), all the statements above concerning consistency and limit values of the estimates remain valid.

Thus, we reach the following conclusion: If investment, z_t, is an autonomous variable, and if $0<\alpha<1$, $m_z>-\beta$, the least squares' regression of c_t on y_t leads to an "estimate," a, of α that has a systematic positive bias, and an "estimate," b, of β that has a systematic negative bias. If we believe that investment, z_t, is an autonomous variable we should rather use, in that case, the consistent estimates (2.14) and (2.15).

Confidence limits for the estimate of α by (2.14) may be derived in the following manner. Let us assume that the distribution of the u's is approximately normal, and that the z's are not random variables. Then the ratio

$$t = \frac{\dfrac{m_{yz}}{m_{zz}} - \dfrac{1}{1-\alpha}}{\dfrac{s}{\sqrt{Nm_{zz}}}} \tag{2.21}$$

has the "Student" t-distribution, with N-2 degrees of freedom. Choosing a certain level of significance, say 5 per cent, we obtain confidence limits for $1/(1-\alpha)$. From these limits we can then derive confidence limits for α itself although, admittedly, this is not the only possible way of obtaining such confidence limits. The choice of confidence interval always depends, to some extent, on the type of statement one wants to make about the unknown parameter. (E.g. one might be more anxious to make a correct statement in the case where α is near to 1 than if α is smaller.)

3. EFFECTS OF INDUCED INVESTMENT

Suppose now that the hypothesis of investment, z_t, being autonomous is not true. Suppose that, instead, the variable z_t consists of two parts, one which is related to current income, and another, q_t say, which is autonomous. Assuming linearity, this alternative can be expressed as follows.

$$z_t = q_t + (\kappa y_t + \lambda + v_t). \tag{3.1}$$

Here the expression in parentheses represents the behavior of those investors whose investment policy depends on current income, y_t. κ and λ are constants, while v_t is a random element such that $E(v_t)=0$, $E(v_t^2)=\sigma_v^2$, for every value of t, and also $E(v_t v_{t-\tau})=0$, $E(v_t u_{t-\tau})=0$, for $\tau \neq 0$. u_t and v_t may, however, be correlated, that is, $E(u_t v_t)=\sigma_{uv}$ may be different from zero. We shall assume that the q's satisfy a condition of the type (2.3). Thus $\bar{m}_{qq}$ is obtained from (2.3) by substituting q for z.

Suppose, first, that the series q_t could actually be observed. Then one could obtain consistent estimates of α, β, κ, and λ, by the following procedure. From (2.1), (2.2) and (3.1) we derive

$$c_t = \frac{\alpha}{1-\alpha-\kappa} q_t + \frac{\alpha\lambda + (1-\kappa)\beta}{1-\alpha-\kappa} + \frac{\alpha v_t + (1-\kappa)u_t}{1-\alpha-\kappa} \tag{3.2}$$

$$y_t = \frac{1}{1-\alpha-\kappa} q_t + \frac{\beta+\lambda}{1-\alpha-\kappa} + \frac{u_t + v_t}{1-\alpha-\kappa}. \tag{3.3}$$

Under the assumptions made these equations satisfy the requirements of the Markoff theorem on least squares, when q_t is taken as the independent variable. If we assume that the sequence q_t is a sequence of constants, we therefore have

$$\frac{m_{cq}}{m_{qq}} = \text{b.u. est. of } \frac{\alpha}{1-\alpha-\kappa} \tag{3.4}$$

$$\frac{m_{yq}}{m_{qq}} = \text{b.u. est. of } \frac{1}{1-\alpha-\kappa} \tag{3.5}$$

$$\frac{m_{qq}m_c - m_{cq}m_q}{m_{qq}} = \text{b.u. est. of } \frac{\alpha\lambda + (1-\kappa)\beta}{1-\alpha-\kappa} \tag{3.6}$$

$$\frac{m_{qq}m_y - m_{yq}m_q}{m_{qq}} = \text{b.u. est. of } \frac{\beta+\lambda}{1-\alpha-\kappa}. \tag{3.7}$$

These estimates are consistent. We, therefore, also have the solutions

$$\frac{m_{cq}}{m_{yq}} = \text{cons. est. of } \alpha, \tag{3.8}$$

$$\frac{m_{yq} - m_{cq} - m_{qq}}{m_{yq}} = \text{cons. est. of } \kappa, \tag{3.9}$$

$$\frac{m_{yq}m_c - m_{cq}m_y}{m_{yq}} = \text{cons. est. of } \beta, \tag{3.10}$$

$$\frac{m_{yq}(m_s - m_q) - (m_{yq} - m_{cq} - m_{qq})m_y}{m_{yq}} = \text{cons. est. of } \lambda. \tag{3.11}$$

It will be observed that the expressions (3.8) and (3.10) are analogous to (2.14) and (2.15).

In Section 2 we compared the results, a and b, of the least squares' regression of c_t on y_t with the consistent estimates, $\hat{\alpha}$ and $\hat{\beta}$, under the assumption that z_t was autonomous. We found that a and b were not consistent estimates of α and β. Now, if a part of z_t is induced the formulae (2.14) and (2.15) will, of course, not give consistent estimates either, the consistent estimates in that case being given by (3.8) and (3.10). It is of some interest to evaluate the large sample bias that would result if we were to apply (2.14) and (2.15) in the present case, and to compare this bias with the large sample bias involved in using (2.16) and (2.17). Let us consider, in particular, the estimates of α. Denote by a_1 the "estimate" of α given by (2.14) if z_t is defined by

(3.1). And let a_2 be the corresponding "estimate" obtained from (2.16). Using (2.1), (2.2), and (3.1), and the properties assumed for the random variables involved, we find

$$\operatorname*{plim}_{N\to\infty} a_1 \equiv \operatorname*{plim}_{N\to\infty} \frac{m_{cz}}{m_{yz}} = \frac{\alpha(1-\alpha)(\bar{m}_{qq}+\sigma_v^2)+\kappa(1-\kappa)\sigma_u^2+\kappa(1-\alpha-\kappa+2\alpha\kappa)\sigma_{uv}}{(1-\alpha)(\bar{m}_{qq}+\sigma_v^2)+\kappa\sigma_u^2+(1-\alpha+\kappa)\sigma_{uv}} \tag{3.12}$$

$$\operatorname*{plim}_{N\to\infty} a_2 \equiv \operatorname*{plim}_{N\to\infty} \frac{m_{cy}}{m_{yy}} = \frac{\alpha(\bar{m}_{qq}+\sigma_v^2)+(1-\kappa)\sigma_u^2+(1-\kappa+\alpha)\sigma_{uv}}{(\bar{m}_{qq}+\sigma_v^2)+2\sigma_{uv}+\sigma_u^2}. \tag{3.13}$$

It is seen that neither of these expressions is, in general, equal to α. The bias depends on the unknown parameters. If we have some a priori knowledge about some of the parameters we can make more definite statements about the bias. Thus, if we assume that $0<\alpha<1$, $0<\kappa<1$, $0<(1-\alpha-\kappa)<1$, and that $\sigma_{uv}>0$, we find that the bias of both (3.12) and (3.13) will be positive. If κ is small compared with α, and σ_{uv} also small, (3.12) will give smaller bias than (3.13), and so forth.

4. A MORE EXPLICIT MODEL

In Section 2 we defined investment z_t in such a way that $y_t=c_t+z_t$. Before making a decision upon the use of this z_t as an autonomous variable, it might be worth-while to examine its content in terms of current statistics of the gross national product and its components.

In the terminology of the U. S. Department of Commerce the gross national product, and disposable income, are defined as follows:[11] (For our purpose here the data should be interpreted as "per capita, in constant dollars.")

Gross national product = Government expenditures (excl. transfer payments)
+ Gross private capital formation
+ Consumers' expenditures.

Disposable income of individuals = Gross national product
− (Total business taxes + personal taxes + employment taxes − transfer payments)

[11] See, e.g., *Survey of Current Business*, May, 1942, p. 12.

−(Depreciation and depletion charges + capital outlay charged to current expense +income credited to other business reserves − revaluation of business inventories + corporate savings).

The total of the five terms in the last parentheses might be termed "gross business savings," or "withholdings." From these definitions it follows that disposable income (y_t) − consumers' expenditures (c_t) $= z_t$ = (Government expenditures + transfers − all taxes + gross private capital formation) − gross business savings. Denoting the total of the four terms in the last parentheses above by x_t, and denoting gross business savings by r_t, we have

$$y_t - c_t = z_t = x_t - r_t. \tag{4.1}$$

The quantity x_t might be called "gross investment." Gross investment is, therefore, here defined as gross private capital formation plus Government net deficit. It might now be argued that it is this "gross investment" which is the exogenous, "dynamic" element, rather than z_t. (That is, one might say that z_t is composed of two parts, one, x_t, which is autonomous, and another, $-r_t$, which is induced.)

To reach a complete model under this hypothesis one has to introduce an additional hypothesis concerning the determination of r_t. Here there might be several possible alternatives. One might, for example, think of r_t as being a function of $(x_t + c_t)$. [The quantity $(x_t + c_t)$ could be called the "gross disposable income" of the private sector of the economy.] Another alternative would be to consider r_t as a function of profits, accumulated business savings, etc. As an illustration of the methodological problems involved in dealing, statistically, with such models let us here adopt the hypothesis that r_t is a linear function of $(x_t + c_t)$. This leads us to the following model.

$$c_t = \alpha y_t + \beta + u_t \tag{4.2}$$

$$r_t = \mu(c_t + x_t) + \nu + w_t \tag{4.3}$$

$$y_t = c_t + x_t - r_t \tag{4.4}$$

$$x_t = \text{an autonomous variable.} \tag{4.5}$$

Here (4.2) is a repetition of (2.2), while (4.3) is the "business-savings" equation. μ and ν are constants to be estimated, w_t being a non-observable random variable. We assume that $E(w_t) = 0$, $E(w_t^2) = \sigma_w^2$, and

$E(w_t w_{t-\tau})=0$, $E(u_t w_{t-\tau})=0$, for $\tau \neq 0$. We do not, however, assume that u_t and w_t are necessarily independent. The sequence x_t, $t=1, 2, \cdots$ is assumed to fulfill a condition of the type (2.3).

Because of (4.4) and (4.5) there are really only two "endogeneous" variables involved. We may take these two variables to be c_t and y_t. Solving the system for c_t and y_t we obtain

$$c_t = \frac{\alpha(1-\mu)}{1-(1-\mu)\alpha} x_t + \frac{\beta - \alpha\nu}{1-(1-\mu)\alpha} + \frac{u_t - \alpha w_t}{1-(1-\mu)\alpha} \tag{4.6}$$

$$y_t = \frac{(1-\mu)}{1-(1-\mu)\alpha} x_t + \frac{(1-\mu)\beta - \nu}{1-(1-\mu)\alpha} + \frac{(1-\mu)u_t - w_t}{1-(1-\mu)\alpha}. \tag{4.7}$$

Under the assumptions made both these equations satisfy the requirements of the Markoff theorem on least squares, if x_t, $t=1, 2, \cdots$, is considered as a sequence of constants. Hence we have

$$\hat{A}_1 = \frac{m_{cx}}{m_{xx}} = \text{b.u. est. of } \frac{\alpha(1-\mu)}{1-(1-\mu)\alpha} \tag{4.8}$$

$$\hat{A}_2 = \frac{m_{yx}}{m_{xx}} = \text{b.u. est. of } \frac{(1-\mu)}{1-(1-\mu)\alpha} \tag{4.9}$$

$$\frac{m_{xx}m_c - m_{cx}m_x}{m_{xx}} = \text{b.u. est. of } \frac{\beta - \alpha\nu}{1-(1-\mu)\alpha} \tag{4.10}$$

$$\frac{m_{xx}m_y - m_{yx}m_x}{m_{xx}} = \text{b.u. est. of } \frac{(1-\mu)\beta - \nu}{1-(1-\mu)\alpha}. \tag{4.11}$$

These equations may, in turn, be solved, to obtain estimates, $\hat{\alpha}$, $\hat{\beta}$, $\hat{\mu}$, $\hat{\nu}$, of the structural parameters α, β, μ, ν, respectively. These solutions are

$$\hat{\alpha} = \frac{m_{cx}}{m_{yx}} \tag{4.12}$$

$$\hat{\beta} = \frac{m_{yx}m_c - m_{cx}m_y}{m_{yx}} \tag{4.13}$$

$$\hat{\mu} = 1 - \frac{m_{yx}}{m_{cx} + m_{xx}} \tag{4.14}$$

$$\hat{\nu} = \frac{m_{yx}(m_c + m_x) - (m_{cx} + m_{xx})m_y}{m_{cx} + m_{xx}}. \tag{4.15}$$

In a similar manner we might estimate σ_u^2, σ_w^2, and σ_{uw}. It will be noticed that the estimation formulae above are very similar to those of Section 3, although the present model has a different economic meaning.

If, as assumed, $Nm_{xx} \to \infty$ as $N \to \infty$, all the estimates above are consistent, by the same type of argument as that of Section 2.

An estimate of a parameter is in itself of little practical value unless it is accompanied by some measure of reliability. What we want is a "confidence region" for the unknown parameters: that is, if we consider all possible simultaneous values of the parameters as points in a parameter space, we want to construct a region, or set of points, which is a function of the observations, and which has a pre-assigned probability of covering the true, but unknown, parameter point. We shall indicate how such a region could be constructed in connection with the model above. We shall consider only the two "essential" parameters α and μ.

Let us first make the assumption that u_t and w_t have a joint probability distribution which is approximately normal. As before, we assume that x_t is a fixed variable. Denote by A_1 the true value of the coefficient $[\alpha(1-\mu)/(1-(1-\mu)\alpha)]$ in (4.6), and by A_2 the true value of the coefficient $[(1-\mu)/(1-(1-\mu)\alpha)]$ in (4.7). And let $\hat{A}_1$ and $\hat{A}_2$ be the corresponding estimates, as given by (4.8) and (4.9). Under the assumptions made the statistics $\hat{A}_1$ and $\hat{A}_2$ will be linear functions of normally distributed variables. $\hat{A}_1$ and $\hat{A}_2$ will, therefore, also be normally distributed. Their means will be equal to A_1 and A_2, respectively. The variance-covariance matrix of $\hat{A}_1$ and $\hat{A}_2$ will depend on σ_u^2, σ_w^2, σ_{uw}, α, and μ. It is then possible to obtain a joint confidence region for α and μ in the following manner.

Let σ_{11} and σ_{22}, and σ_{12} be the variances and the covariance of the residual random elements in (4.6) and (4.7), i.e.

$$\sigma_{11} = E\left[\frac{u_t - \alpha w_t}{1 - (1-\mu)\alpha}\right]^2 \tag{4.16}$$

$$\sigma_{22} = E\left[\frac{(1-\mu)u_t - w_t}{1 - (1-\mu)\alpha}\right]^2 \tag{4.17}$$

$$\sigma_{12} = E\left[\frac{u_t - \alpha w_t}{1 - (1-\mu)\alpha} \cdot \frac{(1-\mu)u_t - w_t}{1 - (1-\mu)\alpha}\right]. \tag{4.18}$$

If the equations (4.6) and (4.7) are fitted to the data by the method of least squares we obtain unbiased estimates, s_{11}, s_{22}, and s_{12}, of σ_{11}, σ_{22},

and σ_{12}, respectively. These estimates are

$$s_{11} = \frac{N}{N-2} \frac{m_{cc}m_{xx} - m_{cx}^2}{m_{xx}} \tag{4.19}$$

$$s_{22} = \frac{N}{N-2} \frac{m_{yy}m_{xx} - m_{yx}^2}{m_{xx}} \tag{4.20}$$

$$s_{12} = \frac{N}{N-2} \frac{m_{cy}m_{xx} - m_{cx}m_{yx}}{m_{xx}} . \tag{4.21}$$

Consider now the statistic T^2 defined by

$$T^2 = Nm_{xx} \sum_{i,j=1}^{i,j=2} s^{ij}(A_i - \hat{A}_i)(A_j - \hat{A}_j) \tag{4.22}$$

where s^{ij} denotes the inverse of the matrix s_{ij}. The distribution of the statistic T^2 is known. More specifically $\{(N-3)/[2(N-2)]\}T^2$ has the F distribution with 2 and $N-3$ degrees of freedom.[12] Choosing a certain level of significance we find the corresponding value of F in Snedecor's table.[13] Let the corresponding value of T^2 be T_0^2. All the points A_1 and A_2 in the parameter space (A_1, A_2) for which $T^2 \leqq T_0^2$ form the area of an ellipse with center at $(\hat{A}_1, \hat{A}_2)$. This is a confidence region for the parameter point (A_1, A_2).

Since the transformation from the (A_1, A_2) plane to the (α, μ) plane is continuous the confidence region derived for A_1, A_2 leads to a corresponding confidence region for α and μ. This transformation is given by the definition of A_1 and A_2. Expressing α and μ in terms of A_1 and A_2, we have

$$\alpha = \frac{A_1}{A_2} \tag{4.23}$$

$$\mu = 1 - \frac{A_2}{1 + A_1} . \tag{4.24}$$

In the next Section we shall give some numerical illustrations.

5. SOME NUMERICAL RESULTS

Some of the methods discussed in the preceding Sections have been applied to U.S. data, partly for the period 1922–41, partly for the period

[12] This fact was pointed out by Dr. T. W. Anderson of the Cowles Commission. See also S. S. Wilks, *Mathematical Statistics*, Princeton University Press, 1943, pp. 234–250.

[13] See G. W. Snedecor, *Statistical Methods*, Ames, Iowa, 1940, p. 184.

TABLE 1

U. S. DATA USED IN STUDY

Year	(1) Disposable income, dollars per capita, deflated y_t	(2) Consumers' expenditure, dollars per capita, deflated c_t	(3) $z_t = y_t - c_t$	(4) "Gross investment" dollars per capita, deflated x_t	(5) Deflator: B.L.S. Cost of Living 1935–39 = 100	(6) U. S. population millions
1922	433	394	39	—	119.7	110.1
23	483	423	60	—	121.9	112.0
24	479	437	42	—	122.2	114.1
25	486	434	52	—	123.4	115.8
26	494	447	47	—	126.4	117.4
27	498	447	51	—	124.0	119.0
28	511	466	45	—	122.6	120.5
29	534	474	60	128	122.5	121.8
1930	478	439	39	97	119.4	123.8
31	440	399	41	81	108.7	124.8
32	372	350	22	45	97.6	125.6
33	381	364	17	45	92.4	126.3
34	419	392	27	66	95.7	127.1
35	449	416	33	78	98.1	128.0
36	511	463	48	103	99.1	128.9
37	520	469	51	98	102.1	129.6
38	477	444	33	83	100.8	130.7
39	517	471	46	105	99.4	131.7
1940	548	494	54	122	100.2	132.8
41	629	529	100	165	105.2	134.0
Sums:						
1922–41	9659	8752	907	—		
1929–41	6275	5704	—	1216	—	—
Means:						
1922–41	482.95	437.60	45.35			
1929–41	482.692	438.769		93.5385		

Second order moments about mean:

1922–41:

$m_{yy} = 3249.65$ $m_{cy} = 2379.25$
$m_{cc} = 1794.35$ $m_{yz} = 870.40$
$m_{zz} = 285.55$ $m_{cz} = 584.90$

1929–41:

$m_{yy} = 4718.23$ $m_{cy} = 3413.69$
$m_{cc} = 2519.85$ $m_{yz} = 2159.62$
$m_{zz} = 1025.92$ $m_{cz} = 1537.85$

Sources of data.

Columns (1), (2), and (3): Years 1929–41 from *Survey of Current Business*, May, 1942, p. 12. Earlier years from unpublished estimates by the Department of Commerce. Deflated, per capita, figures have been calculated by means of Columns (5) and (6).

Column 4: See definition of x_t on p. 114. Years 1929–41 from *Survey of Current Business*, May, 1942, as revised in subsequent issues.

Columns (5) and (6): See, e.g., *Statistical Abstracts of the United States.* (Population figures for 1930–41 have been adjusted for underenumeration of children under 5.)

1929–41. The data used are given in Table 1.[14] Moments used in the calculations are listed in appendix to Table 1. The numerical results given below are numbered so as to correspond to the theoretical formulae given in the preceding, theoretical Sections. These results should, therefore, require little additional explanation.

A. Numerical illustrations to Section 2.

Applying formulae (2.11), (2.14) and (2.15) to the data given in Table 1, we obtain the following estimates

$$\text{(2.11.a)} \qquad \frac{1}{1-\hat{\alpha}} = 3.048 \quad \text{(The "multiplier")}$$

$$\text{(2.14.a)} \qquad \hat{\alpha} = .672 \quad \text{(The marginal propensity to consume)}$$

$$\text{(2.15.a)} \qquad \hat{\beta} = 113.1.$$

Formula (2.13), for $N=20$, gives

$$\text{(2.13.a)} \qquad s^2 = 662.82; \qquad s = 25.7$$

from which we obtain the standard error of $1/(1-\hat{\alpha}) = s/\sqrt{20m_{zz}} = .341$. From tables of the t-distribution, and choosing 5 per cent as the level of significance, we find

$$\text{(2.21.a)} \qquad -2.101 \leqq t = \frac{3.048 - \dfrac{1}{1-\alpha}}{.341} \leqq 2.101,$$

from which it follows that

$$2.33 \leqq \frac{1}{1-\alpha} \leqq 3.76.$$

The corresponding confidence interval for α is

$$.57 \leqq \alpha \leqq .73.$$

For comparison, we have calculated the least squares "estimates," a, and b, obtaining

[14] It will be noticed that, in addition to reducing the figures to a per-capita basis, we have used the Bureau of Labor Statistics cost of living index as a common deflator. By this procedure we do not, of course, mean to imply that the measure of "real investment" thus obtained is a good measure of the physical output of investment goods. The purpose of deflating the current-dollars series by the cost of living index is only to eliminate the effect of a scale factor in all prices, this scale factor being taken to be an autonomous variable. If we postulate that the absolute level of prices should not affect the real volume of consumption, investment, etc. we are—at least in point of principle—free to choose any price index as a common deflator.

(2.16.a) $a = .732$

(2.17.a) $b = 84.0.$

As one might expect [see (2.19) and (2.20)] we find that $a > \hat{\alpha}$, and $b < \hat{\beta}$. Although the difference does not appear to be very large in terms of [illegible] it is considerable in terms of the multiplier $1/(1-\alpha)$, viz. 3.048 versus 3.731.[15]

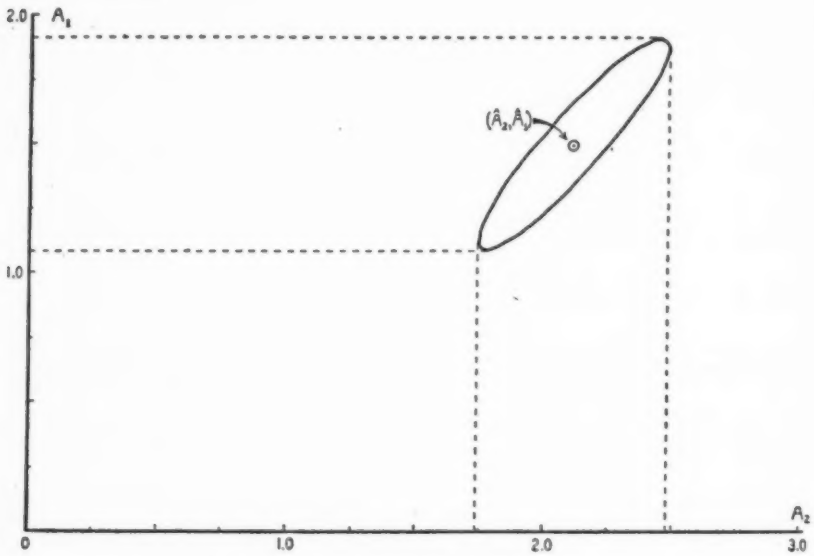

FIGURE 1. JOINT CONFIDENCE REGION FOR A_1 AND A_2. LEVEL OF SIGNIFICANCE 5 PERCENT.

B. Numerical illustrations to Section 4.

Here we consider the model given by (4.2)–(4.5). We use data for 1929–41 only, since the present model requires that the various terms add up in the manner defined by the U. S. Department of Commerce estimates of the gross national product and its components. Consistent data in this respect are available only from 1929. The results obtained are as follows.

(4.8a) $\hat{A}_1 = 1.499$

[15] Although it is not the purpose of the present article to improve upon economic theory it is perhaps of interest to observe that, under the approach outlined above, it is possible to show that also last years' income plays a role as a variable in the consumption function. By a method similar to that used above, treating y_{t-1} as a predetermined variable, one finds $c_t = .57y_t + .16y_{t-1} + \text{const.}$, while the least squares' estimate of this equation yields $c_t = .7y_t + .05y_{t-1} + \text{const.}$

(4.9.a) $\hat{A}_2 = 2.105$

(4.12.a) $\hat{\alpha} = .712$

(4.13.a) $\hat{\beta} = 95.05$

(4.14.a) $\hat{\mu} = .158$

(4.15.a) $\hat{\nu} = -34.30.$

The estimate of α is here slightly higher than that given by (2.14.a), while the estimate of β is, correspondingly, somewhat lower. (For comparison, we have also here calculated the least squares regression of c_t on y_t. The "estimate" obtained for α was .723, which in this case happens to come rather close to the estimate α above.)

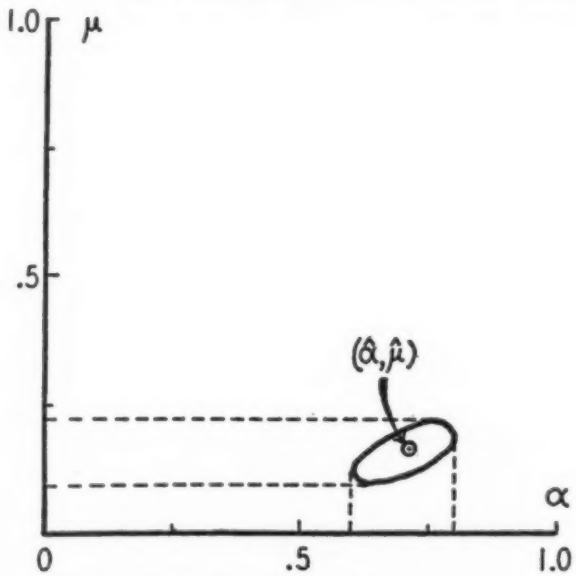

FIGURE 2. JOINT CONFIDENCE REGION FOR α AND μ, CORRESPONDING TO THE REGION IN FIGURE 1.

We shall derive a confidence region for α and μ. For this purpose we have calculated

(4.19.a) $s_{11} = 253.658$

(4.20.a) $s_{22} = 203.439$

(4.21.a) $s_{12} = 208.538.$

Now, $[(N-3)/2(N-2)]T^2$ has the "F"-distribution, $F_{2,N-3}$. In our case $N=13$. Choosing the 5 per cent level of significance, we find from Snedecor's table that $F=4.10$. The corresponding value of T^2 is then $T_0^2=9.02$. Using this and (4.19.a)–(4.21.a) we derive

$$9.02 = 13337[.02507(A_1 - \hat{A}_1)^2 - .05139(A_1 - \hat{A}_1)(A_2 - \hat{A}_2) + .03125(A_2 - \hat{A}_2)^2], \tag{4.22.a}$$

where $\hat{A}_1$ and $\hat{A}_2$ are given by (4.8.a) and (4.9.a). (4.22.a) represents an ellipse in the parameter space of A_1 and A_2. The area covered by this ellipse is the confidence region for A_1 and A_2. It is shown in Figure 1. The corresponding confidence region for α and μ is shown in Figure 2. This latter region was derived numerically by means of the transformations defining A_1 and A_2.

A CRITIQUE OF "A METHOD OF MAKING ACTUARIAL ESTIMATES FOR A COMPULSORY HEALTH INSURANCE SYSTEM"

R. J. MYERS*
Social Security Administration

This note comments on a previous paper in the JOURNAL both as to certain factual errors and as to the general approach in making actuarial cost estimates for social insurance. The considerable complexity of such calculations when adequately prepared is shown although it is indicated that very rough estimates can be made mentally.

IN THE March 1946 issue of the JOURNAL Professor Paul A. Dodd has presented a paper on preparation of actuarial estimates for health insurance. The article implies that it is a relatively simple matter to make actuarial estimates for health insurance. As yet no actuary in this country has made any really extensive estimates of this character, and the author in this paper by no means makes such estimates. Rather he presents estimates for a proposed plan for California, subject to certain criticism as will be brought out later, in regard only to the tax income of such a program and does not concern himself with estimates of benefit outgo or liability which are by far the more difficult portion of the actuarial cost estimates.

There are a number of specific points throughout the paper which are not as "simple" as Professor Dodd would appear to make them. In a number of instances proper estimates involve considerably more complex techniques. Also, there are present in the paper a number of factual and numerical errors.

The first sentence of the paper which reads "The actuarial basis of a compulsory health insurance system, in the final analysis, resolves itself into a problem of simple arithmetic" has the implication that actuarial cost estimates are only a matter of simple arithmetic. It might well be stated in contrary fashion that any cost estimates involving only simple arithmetic are hardly "actuarial"! Illustrations of the complexity of actuarial calculations are the old-age and survivors insurance cost estimates set forth on pages 184–256 of *Issues in Social Security* published by the House Ways and Means Committee in January 1946 and the development of formulas for calculations of premiums and reserves for life insurance as set forth in the actuarial

* The opinions as expressed in this article are those of the author and do not necessarily represent the views of the Social Security Administration.

textbook, *Life Contingencies*, E. F. Spurgeon, Cambridge University Press. Before technicians loosely use the phrase "actuarial estimates," they should realize the vast scope and intricacy of actuarial science. Later Professor Dodd seems to indicate that what he means by simple arithmetic is that in the long run income must balance outgo (which, of course, should be the case for any insurance system), but there still seems to be the implicit assumption that actuarial estimates themselves are simple arithmetic.

If a "snap" estimate based on simple arithmetic were required, an actuary who had sufficient experience in social insurance cost estimates could arrive, through rough mental calculation, at approximately the same result that Professor Dodd obtained after considerable work. Thus, in estimating the tax receipts per worker and the amount available for benefits per eligible person, according to recent experience, the average annual wage per eligible worker would be about $1,500, so a 3% tax would yield revenue of $45 per worker. From a general knowledge of dependency data each worker has an average of one dependent (since those who have no dependents are counterbalanced by the married men with children). As a result, the average funds available per person eligible for medical benefits would then be roughly $22.50.

Professor Dodd emphasizes the basically sound statement that in health insurance, as in any social insurance, all that is offered must be paid for by employers, employees, or the government. An even clearer statement would have been to replace the word "government" by "population as a whole" since some people have the naive view that government contributions are a magic way of eliminating part of the cost from the covered group, whereas actually this is only a method of re-distributing the cost among the covered group and the remainder of the population.

Professor Dodd seems to state that it is a relatively easy matter to determine precisely how much to collect in contributions for a specified plan, or conversely how much to give in benefits for a specified contribution. There is no precise solution, especially in such an unexplored field as health insurance, but when a start is made, all parties concerned should realize that the contribution rates set up or the benefits offered will probably not be in balance and revisions will undoubtedly be necessary in the future.

Professor Dodd states that wages and salaries in California had reached their peak in 1944 and by 1947 will be reduced to a point one-third lower. It is true that 1945 was somewhat lower than 1944, but with the present apparent success of reconversion and the widespread

wage increases that have occurred, there seems a strong likelihood that such a sharp reduction will not take place.

Table 3 contains a number of numerical, factual, and typographical errors as follows:

(a) The headings of the third and fifth columns should have indicated that the $3,000 limit applied only after 1939;

(b) The footnote on the fifth column as to the effect of experience rating reducing the tax rate from 3.7% to 3.15% should have been on the fourth column. Also, it should have been mentioned that this 3.15% applied only to 1944; for example in 1943 the net effective rate was 3.24%. Furthermore, the estimates for 1945–47 in the fourth column are not based on this figure of 3.15% but rather for some unexplained reason on 3.25%;

(c) It should have been indicated in the fourth column that the data relate to payments into the fund in the year, and thus because of the lag between payment of the wages and payment of the taxes to the fund, the third and fourth columns are not strictly comparable. Also, it should have been mentioned that the actual tax payments for 1938 include some taxes for 1937 when the rate was 2.8% rather than the 3.7% subsequently established:

(d) The fifth column which is headed "Estimated Size of Health Insurance Fund on Basis of 3.7% ($3,000 limit)" is in error since the tax rate used was 3% rather than 3.7%. The word "fund" both here and in the last column of the table is not well chosen because in social insurance terminology "fund" means the sum accumulated to a specific date from contributions and interest after deduction of benefit payments and administrative expenses over a period of time, rather than the taxes or contributions collected in a year which is what Professor Dodd meant in these columns.

(e) The figure for 1945 for the sixth column should have been $3,968,000,000 rather than $5,968,000,000.

In addition certain other comments on methodology apply to Table 3. The estimate of unemployment compensation tax payments for 1945–47 is apparently on the basis of the net 3.15% rate actually experienced in 1944 (although the computations, as mentioned above, were based on a rate of 3.25% instead). It is not a simple matter to estimate the trend of the net tax rate after experience rating, but this should be done in order to obtain a more reliable estimate. It seems likely that the net rate would continue the decline shown during recent years as long as employment remains at a relatively high level. Also, it is interesting to note that the actual unemployment compensation tax

payments for the calendar year 1945 were $154.5 million as compared to the estimate of $124.8 million in Table 3, or an excess of 24% of actual over estimated. This is a good indication of the lack of precision and amount of variation which is apt to arise under actuarial estimates for social insurance.

Evidence of the relatively smaller amount of variation of actual experience from estimates for population projections is given by a consideration of Table 4. There the estimated resident civilian population of California for 1945 is set down as 8,004,000 whereas the official Bureau of the Census estimate of this figure is 8,120,000 (as contained in Population Special Reports, Series P-46, No. 3), or a difference of only about 1½%.

In Table 4 there is further evidence that it is not a simple matter to make actuarial cost estimates. There Professor Dodd assumed that the number eligible for unemployment compensation benefits would be 20% greater than the average number employed in covered employment. This relationship was apparently derived for one year or perhaps several years in the past, but most certainly does not remain constant with varying economic conditions. Thus, since the number eligible depends upon wages in a past period of about 1½ years, in time of rising employment the number eligible as related to the number working at a specific date would be less than during a time of falling employment when the number eligible would reflect the higher employment of a year ago and would be measured against the lower employment of the specific date.

In discussing the estimate of the number of dependent spouses and children Professor Dodd points out that it is extremely difficult to arrive at an estimate of what the average per insured worker will be. He then proceeds to take a very simple approach based on an over-all average number of persons per family from the 1940 census and assumes that there will be no variation during the decade considered, although he introduces a factor to allow for variation in the number of dependents per worker according to general employment level. This seems a rather untenable assumption since the average number of persons per family has been decreasing slowly but steadily from census to census and more important because of the drastic effect of the war in reducing, breaking up, and creating families. Proper actuarial technique would involve subdividing the covered employees (rather than dealing with the total gainfully employed, who might have different characteristics) into sex, marital, and broad age groups, based on 1940 census data. Then these data would have to be projected from 1940

on the basis of the higher employment, men entering the armed forces, interstate migration, etc. From this necessarily laborious process there would then be a much better indication of the average number of dependents per employed worker (after eliminating as dependents all working wives and children with husband or father present).

In Table 8 it appears that the heading over the first four columns is not correct and is in fact superfluous; all workers in covered employment are included in the coverage regardless of whether they earn more than $4,000, or only $4,000 and less (as indicated by the heading). Rather the reference to earnings of $4,000 and less should apply to the fifth column since the 3% contribution rate applies only to the first $4,000 of earnings. It seems certain that this is what Professor Dodd meant since his second column in Table 8 is identical with the last column of Table 4 which is the estimated number now eligible for unemployment compensation benefits, while the fifth column in Table 8 is identical with the last column of Table 3 which represents the income from a 3% tax on the first $4,000 of wages. It appears evident, although Professor Dodd nowhere specifically states, that the health insurance plan considered would tax wages up to $4,000 rather than the $3,000 limit in the unemployment compensation system.

Professor Dodd comes to the conclusion that on the average there will be about $23 per year available per person eligible for medical benefits, but there is still the extremely important question remaining as to what benefits can be financed by this amount or more importantly whether the benefits in the Governor's bill can be supported by this approximate income.

LEONARD P. AYRES

AN APPRECIATION

THIS note has been hard to write. The first draft went into the wastebasket, for I had tried to write it in the third person. When you have known someone intimately for thirty years, have worked with him and part of the time lived with him, you can't write objectively. Personal memories keep crowding in, including the memories of a last weekend at our little cottage in Stepney, Connecticut, when we sat around the fire and dissected, through a long sunny afternoon, two of the chapters of the study of the National debt, on which we were both working. After an interval, as had happened so often during such talks, the General pulled out of the air an idea which started us off on a new lead and gave new life and meaning to one of the chapters.

Of course, what seemed a flash of insight was the end result of hours of reflection. When he agreed to write the first chapter on the history of the debt, he unearthed the old reports of the Secretary of the Treasury and verified for himself the figures of the debt and the interest cost. He worked back his own estimates for the national income over one hundred and fifty years. He read the books that have been written about the subject. The flash of insight was built on painstaking analysis.

Few have nurtured so well the art of statistics. Many a night in the early days when the rest of the family were off to bed we left him sitting at the dining room table with his computing machine and tabulating sheets, rolling out with his own hand the evidence on some problem he was eager to solve. He was always seeking new methods—new ways of manipulating figures—new chart forms. I have seen him work for three days to make a diagram that could tell its story precisely and forcefully.

He was never lost, however, in his statistical techniques nor was he overly impressed by them. He made them tools to squeeze the meaning out of the data. He will be remembered as a master of the presentation of statistics. But his mastery was based on patient analysis and reflection which reduced problems to their simplest elements.

Leonard Ayres left his impress on three great human fields—education, economics, and military science. In all three he enlarged the area of knowledge and decreased that of guesswork.

He was a born statistician. As a youngster he made the thrilling discovery of how to do long division, and immediately taught it in the seclusion of a graveyard to a group of little boys, who next day aston-

ished the teacher with their proficiency. His first knowledge of statistics as such came from Roland P. Falkner in Puerto Rico. Leonard went to the Island from college as one of the early group of American teachers. He started as a teacher of English, but within a year became Superintendent of Schools in a large mountain district, and rose rapidly to heavier responsibilities. Roland P. Falkner, then Commissioner of Education, saw his unusual capacities and showed him something of statistics. The spark flashed into a flame that burned steadily for the rest of his life. At the age of 28 he was Superintendent of Schools for the entire island, and was using statistics as an administrative tool; in fact, his studies of pupil retardation broke new ground.

He returned to the United States in 1907, and not long after that was made Director of the Departments of Education and Statistics of the Russell Sage Foundation. There followed a series of reports applying statistical methods to education in ways that jarred loose a whole series of educational practices. His novel and exciting reports included: "Medical Inspection of Schools," "Laggards in Our Schools," "Open Air Schools," "Seven Great Foundations," "The Measurement of Spelling Ability," "A Scale for Measuring Handwriting."

During this period he completed the work for his doctor's degree in Education and was awarded the degree by Boston University.

He became one of the leaders in the making of School Surveys to analyze and evaluate the work of the public schools in a city and recommend betterment. His survey of the Cleveland schools in 1915 and 1916 was one of the most notable.

The first World War opened a new chapter. Leonard Ayres had always been interested in history and especially in military history. He believed statistics could be as useful a tool for winning a war as for reforming education. With the consent of the Sage Foundation, Dr. Ayres took his small staff to Washington even before the United States entered the war, and looked for ways in which he could put his statistical tools and skill to work. Fortunately he knew the Secretary of War, Newton D. Baker, as a result of the Cleveland School Survey; and the Director of the Council of National Defense was Walter Gifford, who had been chief statistician of the American Telephone and Telegraph Company.

Even so, in the catch-as-catch-can of wartime Washington, it took infinite energy and patience and finesse to be allowed to do what you knew needed to be done, for very few people in or out of the Army or Navy or other war agencies knew what statistics was or that they needed it. Dr. Ayres and his staff, which I joined in May, 1917, did what

came to their hands, and fought for the office space to do it in. They installed files; they made organization charts; and increasingly got their hands on statistics which they could analyze and interpret for Mr. Gifford and Mr. Baker. Slowly but surely they proved their case. By the early autumn of 1917 they were rushing weekly reports on procurement of munitions to the Secretary of War and the Chief of Staff and later the President. The reports grew in size and quality and recognition. They became an essential guide in war plans.

In March, 1918, Dr. Ayres became Lt. Col. Ayres, and his expanded office became the Statistics Branch of the General Staff of the Army. To the best of my knowledge he was the first civilian who was ever appointed to that select corps. In a few weeks General Pershing heard of the new methods by which executives could know quickly where the procurement and man power programs stood, and asked to have Lt. Col. Ayres assemble a small staff and bring them to G.H.Q. at Chaumont and organize an office there. Statistics had reached the heart of the Army and played its part in the victory. The Statistics Branch became a permanent fixture in the tables of organization of the General Staff. Leonard Ayres was soon a full Colonel in the General Staff Corps.

Back in the United States a few weeks before Armistice, Colonel Ayres was not allowed to stay long. He went to Paris as chief statistical officer of the American Commission to Negotiate Peace.

While most of Colonel Ayres' work in the Army was strictly secret and for executive use only, a final report was published in 1919, "The War With Germany—A Statistical Summary." There the outside student may see the explanation of how and why statistics demonstrated its worth to the Army. For his service he was awarded the Distinguished Service Medal.

After another year back at the Sage Foundation (1919–1920) Colonel Ayres moved to a new field in which he won his greatest recognition. Clevelanders who had seen the results of the school survey and knew his work in Washington persuaded him to become Vice President of the Cleveland Trust Company.

The application of statistical methods and imagination to business and banking bore much fruit. The Cleveland Trust Company *Bulletin*, written for twenty-five years almost entirely by Colonel Ayres, earned a unique place. Every month the papers over the country learned to watch for Colonel Ayres' statement on business.

Besides the *Bulletin* there was a series of special reports on matters of current interest and two books: *The Economics of Recovery* in 1933 and *Turning Point in Business Cycles*—1939.

The publications were far from being his chief occupation, for he was an executive Vice President of the Trust Company and became economic advisor to the Chesapeake and Ohio and the Alleghany Corporation (later a director of both). Through all the years as educator and banker he repeatedly refused offers of presidencies of universities or of other important organizations with impressive titles and salaries. His reason was always the same, "I am a statistician. If I took that job I shouldn't have time for statistics."

His intellectual leadership in banking was early recognized and from 1932 to 1941, and later from 1944 to his death he was chairman of the Economic Policy Commission of the American Bankers Association. His semi-annual reports for that committee were quantitative analyses of banking problems and were accepted by bankers as a sound guide to their operations.

When the Bankers Association started a summer Graduate School of Banking for the post graduate training of selected bank officers, Colonel Ayres' address became an annual feature. He spoke each year from 1936 to 1946 to an enthusiastic group of young men.

In December of each year that he was in Cleveland he spoke before the Cleveland Chamber of Commerce, always to a crowded house, and made his annual business prediction for the coming year. It was part of his credo that the statistician had a responsibility to make his art practically useful. Businessmen are obliged to forecast the future in placing their orders, building plants, and hiring and training workers. The statistician to be useful must help business make these decisions. That was why he made his annual predictions. He deliberately put himself in a position where he had to make the forecasts the business man needed.

For many years he spoke in like vein at the annual meeting of the American Statistical Association—at the lunch or dinner which Fred Mills described in the doggerel "Friday, and Edie, and Ayres." He was intensely loyal to the Association and the profession. A member for 40 years, a Fellow for most of that time, President in 1926, he attended most of the annual meetings, and supported his local chapter. Back in the Russell Sage days Education was the most frequent topic for statistical meetings; he was partly responsible. Later the trend was to Economics; he helped stir that up. Lest I forget to say it, he was a fighter. As an educator he ripped open some school practices, and did it with a sharp tongue and pen that brought results—and some controversy and enemies. Anybody who wants to can find samples in the pages of the Cleveland Trust *Bulletin* when he was discussing some new and fanciful

economic theory. Or get out his Presidential address in 1926, when he was concerned "that statisticians appeared to find a negative correlation between ability and lucidity."

Twice after World War I he was called on by his Government for special service. In 1924 he went to Paris as Economic Advisor for the American Commission negotiating the Dawes Plan. Then in October 1940 the Secretary of War called him back to active duty to organize a statistical service for the great defense program; in World War II they knew they needed statistics. He was one of the few officers who held a similar post to that in World War I. In 1941 he was given the rank of Brigadier General.

He served until retired for age in 1942, with health not improved by working through Washington summers, ten hours a day, seven days a week. He returned to his work in Cleveland and his other forms of public service. One of the last products of his pen was a chapter on the history of the National debt for the Committee on Public Debt Policy.

In three fields of activity General Ayres' work was solid and valid and, more than that, carries the conviction of great simplicity and power of phrase. It has changed the decisions of men—has made us more conscious of the character of our world and the kind of action we need to make it better.

To statisticians he has left a heritage of fine methods of work, of sharpened statistical tools, of intellectual integrity.

But that tells only half the story. His life and his work lives in many people who were his students and his disciples. He was a quiet, reserved, rather shy person. He seldom sought out other people; they had to seek him. But for his friends and for young people especially he took infinite pains; to teach them, to help them, to guide them. He had a quiet charm, shot through with golden sparks of humor, that was irresistible.

When we were organizing the statistical office for World War I a rosy cheeked young man came to us from Minnesota. He had tried a half dozen times to enlist in as many places, but he had a leaky heart, and so he stayed with us and worked night and day on the raw material for war. A few years ago, before the heart finally gave out, he visited Leonard Ayres in Cleveland, and we found the following letter among the General's papers. Fred wouldn't mind my using it here.

"Dear Colonel:

It's a good thing for you that I'm getting out of this town, because if I stayed much longer I'd get completely 'under' your spell again and be begging you for a job. I'm quite sure I've been doing the thing I'm best fitted for, but for sheer fun nothing equals the times at the Council and the Crillon when I got a chance

to see you everyday. I've worked for some able men since from John Hays Hammond and Moulton to Mr. Hoover, but I never got quite the same sense of surefooted leadership. You had an uncanny magnetism then, and time hasn't weakened it and one evening's reunion makes me as wholly yours to command as ever.

With sincerest affection,

FRED TRYON."

Leonard Ayres' life is a record of achievement, and only a few knew him intimately enough to sense the mainspring of the great sustained and effective drive which brought these results. No man can really interpret another, but some of us who knew him best felt his burning patriotism, his desire to see his country a better place to live in, and with it all a profound faith in the power of the written and spoken word—a belief that basically the human being is a rational animal, and if you can get the facts before him, simply and clearly, he will make the right decisions. He believed, to put it another way, that the statistician has a great mission, that of helping others to understand.

The poet Horatius Bonar has a few lines which come close to stating his belief:

"Think truly, and thy thoughts
Shall the world's famine feed.
Speak truly, and each word of thine
Shall be a fruitful seed.
Live truly, and thy life shall be
A great and noble creed."

W. RANDOLPH BURGESS

New York City

PROCEEDINGS

106TH ANNUAL MEETING

CHALFONTE-HADDON HALL, ATLANTIC CITY, NEW JERSEY

PROGRAM

Statistics and Peacetime Democracy

Friday, January 24, 1947

Meetings of the American Statistical Association were arranged in several series for the convenience of members attending them. The subject of each meeting is marked by a capital letter indicating in which series the meeting was planned. The following are the series letters and description:

A. Improvement and Extension of Statistical Data
B. Statistics in Social and Opinion Research
C. Developments in Statistical Methodology
D. Business and Industrial Applications of Statistics
E. The Biometrics Section—Statistics in Biology
F. Business and Other Meetings

—10:00 A.M.—

(F) MEETING OF BOARD OF DIRECTORS AND OFFICERS

—12:30 P.M.—

(F) MEETING OF EDITORIAL BOARD

—2:30 P.M.—

(A) PROBLEMS IN PROVIDING ADEQUATE STATISTICS ON EMPLOYMENT AND EARNINGS

Chairman: N. Arnold Tolles, The American University

Employment and Labor Force

Problems of Measuring Employment by Labor Force and Establishment of Reporting
Samuel Weiss, Bureau of Labor Statistics
Household Enumeration with Special Reference to the Self-Employed
Emmett Welch, Bureau of the Census

Wage Rates and Earnings

Wage and Earnings Statistics and Their Uses
Harry M. Douty, Bureau of Labor Statistics
Discussion of Wage Statistics and the Cost of Fringe Settlements
Solomon Barkin, Textile Workers Union of America
Stephen DuBrul, General Motors Corporation

General

Discussion: Jules Bachman, New York University
Louis J. Ducoff, Bureau of Agricultural Economics
Martin R. Gainsbrugh, National Industrial Conference Board
Clark Kerr, University of California

(B) PUBLIC ATTITUDES ON THE ATOM BOMB

Chairman: Frederick F. Stephan, Cornell University

Survey Using Standard Polling Procedures
Richard Crutchfield, Swarthmore College
Research Using Open-Ended Questions and Informal Interviews
Angus Campbell, University of Michigan
Comparison of the Findings by the Two Research Methods
Leonard S. Cottrell, Jr., Cornell University

Discussion: Paul F. Lazarsfeld, Columbia University

(E) APPLICATIONS OF STATISTICAL TECHNIQUES TO AGRICULTURAL ECONOMICS

(Biometrics Section, Joint Session with Econometric Society and the Institute of Mathematical Statistics)

Chairman: Holbrook Working, Stanford University

Use of Variance Components in the Analysis of Market Differentials in Hog Prices
R. L. Anderson, University of North Carolina
An Application of the Analysis of Variance in the Economic Evaluation of Production
Boyd Harshbarger, Virginia Polytechnic Institute
A Model of the Economic Interdependence between Agriculture and the National Economy
Trygve Haavelmo, Cowles Commission for Research in Economics
The Reduced-Form Method for Estimating Simultaneous Economic Relationships
M. A. Girshick, Bureau of the Census

Discussion: T. W. Anderson, Columbia University
Harold Hotelling, University of North Carolina

(D) STATISTICAL REQUIREMENTS FOR SMALL BUSINESS ANALYSIS

Chairman: A. D. H. Kaplan, Brookings Institution

The Salvage of Wartime Data Bearing on Small Business
Samuel Nakasian, Bureau of the Budget
Henry A. Peel, Office of Temporary Controls
Financial Statistics on Smaller Business
William W. Cooper, Carnegie Institute of Technology
Problems of Measuring Smaller Business
E. J. Engquist, Jr., Frank A. Hanna, and Ralph C. Janoschka, Bureau of the Census

Increasing the Usefulness of Data
J. C. Dockeray, Office of Small Business, Department of Commerce
Edwin George, Dun & Bradstreet

Discussion: E. B. Hincks, Bureau of the Budget
B. J. Mandell, Social Security Board
Wilford White, Small Business Advisory Committee

—8:00 P.M.—

(C) (E) WHEN IS THE ANALYSIS OF VARIANCE USEFUL IN ECONOMIC RESEARCH? (Joint session with Econometric Society and Institute of Mathematical Statistics)

Chairman: Arthur R. Tebbutt, Northwestern University

The Advantages of the Analysis of Variance for Research and Managerial Control Purposes
Harry Pelle Hartkemeier, University of Missouri
Estimation of Economic Relationships and Multivariate Regression
Leonid Hurwicz, Iowa State College

Discussion: Tjalling Koopmans, Cowles Commission for Research in Economics
Gerhard Tintner, Iowa State College
J. W. Tukey, Princeton University

(A) PROBLEMS IN PROVIDING ADEQUATE STATISTICS ON NON-AGRICULTURAL PRODUCTION

Chairman: Arthur R. Burns, Columbia University

The Federal Reserve Board Index of Industrial Production
Lorman Trueblood, Board of Governors, Federal Reserve System
Report on the Productivity Conference
Solomon Fabricant, National Bureau of Economic Research, Inc.
Statistics of Production for Manufacturing and Mining
David Novick, Civilian Production Administration

(B) PROBLEMS IN MEASURING OPINION THROUGH MAIL QUESTIONNAIRES AND INTERVIEWS

Chairman: Clyde Hart, National Opinion Research Center

Bias Arising From Different Forms of Survey Samples
Raymond Frandzen, Statistical Consultant
The Use of the Mail Questionnaire in Social Research
John A. Clausen, Cornell University
Robert H. Ford, U. S. Veterans Administration
Advantages and Limitations of Repeated Interviews
Bernard Berelson, University of Chicago
On Setting Up Consumer Panels
Marion Harper, Sr., Marketing Studies, Inc.

Saturday, January 25, 1947

—10:00 A.M.—

(A) PROBLEMS IN PROVIDING ADEQUATE STATISTICS ON PRICES AND CAPITAL FLOW

Chairman: Milton Gilbert, Department of Commerce

Retail and Wholesale Prices
Aryness Joy Wickens, Bureau of Labor Statistics
Savings and Investment
Homer Jones, Committee for Economic Development
Tynan Smith, Federal Deposit Insurance Corp.
Business Profits
Susan Burr, Board of Governors, Federal Reserve System

(B) SOCIAL SAMPLING OVERSEAS

Chairman: Dorwin P. Cartwright, Massachusetts Institute of Technology

Survey of Psychological Effects of Bombing in Germany
Daniel C. Katz, Brooklyn College
Survey of Psychological Effects of Bombing in Japan
Burton R. Fisher, Yale University
On a Population Sample for Greece
Raymond J. Jessen, Bureau of Agricultural Economics
and Iowa State College
Richard H. Blythe, Jr., Federal Trade Commission

(B) USE OF SURVEY TECHNIQUES FOR ECONOMIC RESEARCH

Chairman: Rensis Likert, University of Michigan

Value and Limitations of Survey Results
Ralph A. Young and Duncan McC. Holthausen, Board of Governors,
Federal Reserve System
Contributions of Psychological Data of Economic Analysis
George Katona, University of Michigan
Sampling for the Liquid Assets Survey
J. Roe Goodman, University of Michigan
Interviewing Methods Employed in the Liquid Assets Survey
Eleanor Maccoby, University of Michigan

Discussion: Fritz Machlup, University of Buffalo
Morris H. Hansen, Bureau of the Census

(C) USE OF ORDERED OBSERVATIONS IN STATISTICAL ANALYSIS
(With the Institute of Mathematical Statistics)

Chairman: Harold Hotelling, University of North Carolina

Estimation of Parameters by Use of Order Statistics
Frederick Mosteller, Harvard University
Tolerance Limits
Jacob Wolfowitz, Columbia University
The Asymptotic Distribution of the Range
E. J. Gumbel, Newark College of Engineering

Discussion: Joseph Berkson, Mayo Clinic
Howard L. Jones, Illinois Bell Telephone Co.
Jerzy Neyman, University of California
F. E. Satterthwaite, Aetna Life Insurance Co.
John W. Tukey, Princeton University
John H. Smith, Bureau of Labor Statistics

—12:30 P.M.—

(F) LUNCHEON: COMMITTEE ON CENSUS ENUMERATION AREAS

Chairman: Howard Whipple Green, Cleveland Health Council & Cleveland Real Property Inventory

Retrospect and Prospect
Leon E. Truesdell, Bureau of the Census
Tracting in the Metropolitan Ring
C. E. Batschelet, Bureau of the Census
Reports from the Census Tract Cities
Florence E. Cuttrell, Horace C. Fehr, H. W. Green, Werner Hockwald, O. A. Lemieux, J. A. Quinn
A Review of the Work of the Committee in 1946
Howard Whipple Green
Sound Movie on the *Use of Census Tracts*
Guy E. Marion, Los Angeles Chamber of Commerce

—2:00 P.M.— (B)

(E) BIOMETRICS SECTION: CONTRIBUTED PAPERS

Chairman: Chester I. Bliss, Connecticut Agricultural Experiment Station

The Application of Measures of Dispersion and Correlation to Index Numbers
Zenon Szatrowski, Northwestern University
Cost Utility as a Measure of Efficiency of Selection for a Dichotomous Grouping
Joseph Berkson, Mayo Clinic
The Transformation of Qualitatively Different Criteria of Biological Response to a Continuous Scale
Johs. Ipsen, Department of Biological Standards, Denmark

—2:30 P.M.— (B)

(A) THE PROBLEM OF IMPROVING BASIC STATISTICS AND THEIR PRESENTATION

Chairman: A. Ford Hinrichs, The Kiplinger Organization

The Need for Reconciliation of Data

Conflicting Estimates of Construction Volume
Miles Colean, Construction Consultant
Payroll-Employment and Production Statistics
A. D. H. Kaplan, Brookings Institution

The Problems of Reconciling Basic Statistics

Standardization of Classification, Sampling, and Timing
Ezra Glaesser, Bureau of the Budget
Administrative Statistics and Economic Analysis
William R. Leonard, Statistical Office, United Nations
Authority and Compromise as Tools of Administrative Action
Morris A. Copeland, National Bureau of Economic Research

General Problems of Improving Data at the Basic Level

Sample versus Census Techniques
Philip M. Hauser, Department of Commerce
Checking with Data Collected by Private Organizations
Martin Gainsbrugh, National Industrial Conference Board
The Division of Statistical Standards Program for Presentation of Data
Donald C. Riley, Bureau of the Budget

The Responsibility of Users of Inadequate Data

Going to the Fire with Statistics
Kenneth Galbraith, Fortune Magazine
Testing Data as a Prerequisite to Use
Richard Heflebower, Brookings Institution

Discussion: Oscar E. Kiessling, Machinery and Allied Products Institute

(B) Full Employment Patterns in 1950

A Study of the Industrial Structure of the American Economy

Chairman: Gerhard Colm, President's Council of Economic Advisers

Assumption of Procedures
Marvin Hoffenberg, Bureau of Labor Statistics
Results and Implications
Duane Evans, Bureau of Labor Statistics

Discussion: Morris Copeland, National Bureau of Economic Research
Everett Hagen, Bureau of the Budget
Ernst Swanson, U. S. Chamber of Commerce

(B) Recent Developments in Radio Research

Chairman: Frank Stanton, Columbia Broadcasting System

A Statistical Foundation of Listening Indexes
Hans Zeisel, McCann-Erickson, Inc.
Kenneth Greene, National Broadcasting Co., Inc.
Recent Experience in the Use of the Program Analyzer
Oscar Katz, Columbia Broadcasting System
Future Developments of Research with the Program Analyzer
Herta Herzog, McCann-Erickson, Inc.

(D) BUREAU OF BUSINESS RESEARCH, FUNCTIONS AND GENERAL FRAMEWORK MOST CONDUCIVE TO SUCCESSFUL OPERATION

Chairman: F. L. Carmichael, University of Denver

The Role of a Bureau of Business Research in the University and in the Community
G. W. Starr, Indiana University
Henry B. Moore, University of Colorado
The Content of a Well-Rounded Curriculum in Statistics
H. K. Allen, and William A. Neiswanger, University of Illinois
H. H. Chapman, University of Alabama
Working Arrangements for Maximizing Contributions of Faculty and Students to Bureau Programs
John H. Cover, University of Maryland
Specifics for the Development of an Effective Bureau Program
J. P. Watson, University of Pittsburgh

—6:00 P.M.—

(F) TESTIMONIAL DINNER

Toastmaster: Joseph S. Davis, Food Research Institute

Guests of Honor: Irving Fisher, Walter Willcox

Tributes: E. Dana Durand, U. S. Tariff Commission
Ragnar Frisch, Oslo University

Presidential Address:
Social and Economic Adjustments in a Democratic World
Isador Lubin

—7:30 P.M.—

(F) ANNUAL BUSINESS MEETING

Sunday, January 26, 1947

—8:30 A.M.—

(F) BREAKFAST—MEETING OF CHAPTER REPRESENTATIVES

Chairman: Lester S. Kellogg, Secretary-Treasurer of the American Statistical Association

The New Constitution and Its Implications for the Chapters
Willard L. Thorp, President of the American Statistical Association
The Challenge of an Increased Membership
Lester S. Kellogg
Discussion of Chapter Problems

—10:00 A.M.—

(A) PROBLEMS IN PROVIDING ADEQUATE STATISTICS ON AGRICULTURE

Chairman: O. C. Stine, Bureau of Agricultural Economics

Agricultural Estimates
Thomas C. M. Robinson, Bureau of Agricultural Economics

Agricultural Price Index Numbers
Arthur G. Peterson, Army Industrial College
Consumption of Agricultural Commodities
James P. Cavin, Bureau of Agricultural Economics
The Agricultural Census
Morris H. Hansen, Bureau of Census

(B) MEASUREMENT SCALES IN ATTITUDE RESEARCH

Chairman: Samuel A. Stouffer, Harvard University

Scaling and Intensity Analysis
Louis Guttman, Cornell University
The Reduction of an Aggregate of Items to One Latent Attribute
Paul F. Lazarsfeld, Columbia University

Discussion: C. W. Churchman, University of Pennsylvania
Frederick Mosteller, Harvard University

(D) BUREAUS OF BUSINESS RESEARCH: SPECIFIC PROPOSALS FOR STRENGTHENING THEIR PROGRAMS

Chairman: John H. Cover, University of Maryland

Development of Comparable Regional Indexes of Business Activity
G. I. Butterbaugh, University of Washington
Furtherance of Cooperative Relationships with Regional Research Agencies
Robert W. French, University of Texas
Furtherance of Cooperative Relationships with Federal Agencies
Francis R. Cella, University of Oklahoma
Viva Boothe, Ohio State University
Wilford White, Department of Commerce

(F) THE TRAINING OF STATISTICIANS—ROUND TABLE

Chairman: Helen M. Walker, Teachers College, Columbia University

Participants: Chester I. Bliss, Connecticut Agricultural Experiment Station
Francis J. Brown, American Council on Education
Francis G. Cornell, U. S. Office of Education
Stephen DuBrul, General Motors Corporation
Harold Hotelling, University of North Carolina
Walter J. McNamara, International Business Machines, Inc.
Jerzy Neyman, University of California
James D. Paris, Metropolitan Life Insurance Company
C. V. Taylor, Civil Service Commission
S. S. Wilks, Princeton University

—2:30 P.M.—

(A) PROBLEMS IN PROVIDING ADEQUATE STATISTICS IN HOUSING AND HOME TENANCY

Chairman: Ernest M. Fisher, Columbia University

Statistical Requirements of Public Housing
Lawrence Bloomberg, Federal Public Housing Authority

Some Statistical Implements for Housing and Home Finance
James C. Downs, Jr., Real Estate Research Corporation

Discussion: Miss Katherine Perring, Federal Housing Administration
L. Durward Badgley, Mutual Life Insurance Company of New York
Leo Grebler, Washington, D. C.

(D) USE OF THE "ECONOMIC ANALYZER" IN INTERPRETING THE EFFECTS OF RAPIDLY CHANGING PRICES ON CONSUMER DEMAND

Speaker: Ivan Tarnowsky
The "Economic Analyzer" is a flexible chart for portraying income flows through the economy of a single firm in a similar pattern for comparable analysis.

(D) FEDERAL AGENCY ACTIVITIES SERVICEABLE TO BUREAUS OF BUSINESS RESEARCH

Chairman: R. W. Coleman, Department of Commerce

Ewan Clague, Commissioner of Labor Statistics
Philip M. Hauser, Department of Commerce
O. C. Stine, Bureau of Agricultural Economics
Watrous H. Irons, Federal Reserve Bank of Dallas

(F) MEETING OF OFFICERS AND BOARD OF DIRECTORS OF THE AMERICAN STATISTICAL ASSOCIATION

MINUTES OF THE ANNUAL BUSINESS MEETING

The American Statistical Association convened for its 106th Annual Business Meeting at dinner at 6:00 P.M., Saturday, January 25, 1947, in the Vernon Room of Chalfonte-Haddon Hall in Atlantic City, New Jersey. The meeting was the occasion of a Testimonial Dinner in honor of Professor Irving Fisher and Professor Walter F. Willcox. Professor Joseph S. Davis presided as Toastmaster and there were 160 members and a number of foreign statisticians present to do honor to the guests.

Professor Ragnar Frisch, of the University of Norway at Oslo, Norway, and the United Nations spoke on Professor Irving Fisher and Commissioner E. Dana Durand, of the United States Tariff Commission, spoke on Professor Walter F. Willcox. Their remarks are printed on page 2 of this issue.

Immediately after the dinner, Joseph S. Davis read the following report of the Committee on Fellows:

The Committee on Fellows has elected the following nine members as Fellows of the American Statistical Association:

Calvert L. Dedrick, Coordinator of International Statistics of the Bureau of the Census in Washington, D. C. Mr. Dedrick is active in planning for the 1950 Census of the Americas as Chairman of the Committee of the Inter-American Statistical Institute dealing with the Census of the Americas. He was Research Director of the Census Bureau for the Census of 1940. During the war he was Chief of the Statistics and Economics Unit, Office of the Provost Marshal General. His Doctor's degree is from the University of Wisconsin.

Stephen M. DuBrul, of the Economic and Social Division of General Motors Corporation. Specialist in industrial statistics for the guidance of business in analysis of its own operations and of problems of economics affecting business. Formerly Acting Director of Research and Statistics of the National Recovery Administration. Graduate of the University of Michigan.

Meyer A. Girshick, United States Bureau of the Census. Statistical expert in the Office of the Statistical Assistant to the Director. Formerly agricultural statistician with the Bureau of Agricultural Economics in Washington. Specialist in mathematical statistics. Graduate of Columbia University. Instructor in the Graduate School of the U. S. Department of Agriculture.

Irving Lorge, Professor of Education at Teachers College, Columbia University, and Executive Officer of the Institute of Psychological Research at that institution. Expert in the development of the selection, classification and achievement testing program for Army personnel during the war and special consultant to the Secretary of War; now special consultant also to other Government Departments in this field. Author and editor in educational research and applied psychology and originator of statistical methods in this field. Collaborator of the New York Sugar Trade Laboratory for the statistical development of the Zerban, Sattler, and Lorge international standard method for determining sugar ash.

William G. Madow, formerly of Washington, D. C., now United States Consul at São Paulo, Brazil, and visiting professor at the University of São Paulo. Formerly a member of the staff of the Bureau of the Census, of the

U. S. Department of Agriculture, as well as working with the Social Security Board and the Office of Price Administration. Mathematical statistician specializing in the field of population. On his return from Brazil, Mr. Madow expects to become an associate professor of the new Department of Mathematical Statistics of the University of North Carolina.

Howard B. Myers, Associate Director of Research and Executive Secretary of the Research Committee, Committee for Economic Development. Formerly Assistant Director of the Statistics Division of the War Production Board, in charge of measures of progress of the war program; Director of Research for the Works Progress Administration. Specialist in social and economic statistics. Formerly professor and a member of the statistics faculty of the Graduate School of the American University in Washington. His doctor's degree is from the University of Chicago.

Gladys L. Palmer, Research Associate of the Wharton School of Commerce and Finance of the University of Pennsylvania, and Chairman of the Technical Committee on Labor Supply, Employment and Unemployment Statistics of the Division of Statistical Standards of the U. S. Bureau of the Budget in Washington. Formerly a member of the faculty of Vassar College, Hollins College, and the Pennsylvania College for Women. Specialist in employment statistics. Graduate of Columbia University, Ph.D., University of Pennsylvania.

Faith M. Williams, Director of the Foreign Labor Conditions Staff of the U. S. Bureau of Labor Statistics, and formerly Chief of the Cost of Living Division. Formerly with the U. S. Bureau of Home Economics. Specialist in the cost of living, consumption statistics, and international statistics and economics. Her doctor's degree is from Columbia University.

Joseph Zubin, Research Psychologist, New York State Psychiatric Institute and Hospital, and Instructor in Psychiatry, College of Physicians and Surgeons, Columbia University. Active in medical, psychological and psychiatric statistics. Graduate of Johns Hopkins University, Ph.D. from Columbia.

LOWELL J. REED, *Chairman*
ARYNESS JOY WICKENS, *Acting Chairman*
HENRY B. ARTHUR
JOSEPH S. DAVIS
HAROLD HOTELLING

Dr. Isador Lubin, President of the Association for 1946, delivered his Presidential Address, *Social and Economic Adjustments in a Democratic World*,* after which the meeting proceeded to the business of the evening with Dr. Lubin presiding.

Dr. Stuart A. Rice, U. S. representative on the Statistical Commission of the United Nations and Chairman of the U. S. Arrangements Committee for the Twenty-fifth Session of the International Statistical Institute, announced that plans were being made for a World Statistical Congress in Washington, D. C., in September, 1947, simultaneously with meetings of the International Statistical Institute and the Inter American Statistical Institute.

* Printed on page 11 of this issue.

The Secretary, Lester S. Kellogg, gave a brief report on the current status of finances and membership of the Association.

The report of the Temporary Committee on Statistical Standards, approved by the Board of Directors at its meeting on Friday, January 24, 1947, was read by Doctor Lubin:

> Your Committee recommends to the Board of Directors of the American Statistical Association that it establish a Standing Committee on Standards to be a permanent part of the organizational pattern of the American Statistical Association.
>
> It is the opinion of your Committee that there is a need for a body of such professional standing that its judgment would be acceptable to workers in the field of statistics and to the public at large. There should be continuity in such a Committee and it is recommended that it be small enough to make it possible for a large proportion of the membership to take part in its deliberations. This Committee tentatively recommends that the Standing Committee have a membership of about nine persons, representative of the various fields of statistics.
>
> It is the opinion of the Committee that the Standing Committee should have rotating membership based on a three year term; one-third of the initial membership to be appointed for one year, one-third for two years, and one-third for three years. Members should be eligible to reappointment. Election should be made by the Board of Directors after consultation with the Committee.
>
> The functions of the Committee should be:
>
> A—To provide a tribunal to render opinions and recommendations on controversial issues relating to statistical procedure and presentation of statistical material.
>
> B—Develop a list of minimum standards for published statistical materials.
>
> C—Upon request from governmental bodies, review actual or proposed undertakings and make recommendations relative to standards.
>
> The Committee might eventually develop a code of ethical practices in statistical work.
>
> During the early stages of its existence, it is felt that the Standing Committee should not act as a body for passing judgment upon the quality of individual undertakings except in those instances where a controversy exists. In other words, it should not devote itself to rendering free services to any person or organization desiring guidance in the field of statistics.
>
> The Standing Committee should have the right to act on its own initiative or upon the request of responsible outside individuals or organizations.
>
> In carrying out its work, it should have the right to appoint ad hoc subcommittees of specialists to investigate any controversy which, in its opinion, merits its attention.
>
> To render the type of service we have in mind, the Committee on Standards will obviously require funds. Such funds, we feel, will be necessary to take care of the salary of an executive officer and such secretarial aid as will be required as well as to cover the expenses of any ad hoc sub-committees it may appoint. It is probable that during the early stage of its existence, a part-time executive officer is all that will be required.
>
> It is the feeling of the Committee that a Standing Committee on Statisti-

cal Standards will result in definite contributions to our science. For example, it will, no doubt, in many instances necessarily have to point to gaps in existing information, thereby stimulating the collection and production of certain types of information that are not available. In other instances, it would reveal the use of existing data for purposes for which they were never intended, or would reveal the fallacy of findings arrived at through the use of inadequate methods of analysis. It can make a definite contribution to the development of uniformity in statistical terms and in the collection of statistical data bearing upon identical problems.

The newness of the venture your Committee is recommending requires that the policies and procedures of the Committee on Standards should be broad and flexible and determined by the Committee itself, subject to the right of reconsideration by the Board of Directors. Only through actual experience will it be possible to determine the best methods of procedure and the exact limits of the fields to be handled by the Committee. Its methods of procedure will develop from its experiences. Since in the final analysis its terms of reference will be subject to the approval of the Board of Directors, there should be no hesitancy about giving the Committee the widest possible latitude in developing its procedures and lines of activities.

The report of the Committee was approved after some discussion and recommendations that the standing committee to be appointed be expanded to include subcommittees of Association Fellows who would work on the development of standards.

Willard L. Thorp, reporting for the Committee on Structure, stated that the Committee had prepared a revised draft of a new Constitution for discussion by the membership, and that the final draft will be submitted to the membership for a mail ballot. The meeting was opened to general discussion of the draft Constitution. A number of recommendations were made for changes in wording. Dr. Thorp agreed to take account of all suggestions received by the Committee in preparing the final draft of the Constitution.

Chester I. Bliss, for the Committee on Resolutions, proposed the following statement:

> RESOLVED that the American Statistical Association express to Edward Bloom and to J. Weldon Hoot of Philadelphia its appreciation for their services in making the local arrangements for these meetings.
>
> CHESTER I. BLISS
> SAMUEL A. STOUFFER

The resolution was passed unanimously.

Frederick F. Stephan, chairman of the Nominating Committee, read the following slate of officers proposed for 1947:

President, Willard L. Thorp; Vice-Presidents, Chester I. Bliss, Philip M. Hauser, Stacy May, Jacob Marschak, Jerzy Neyman, Frank W. Notestein, George W. Snedecor, Aryness Joy Wickens; Directors, Isador Lubin, Lowell J. Reed (for three year terms), and Samuel S. Wilks (for the balance of Dr. Thorp's term), Secretary-Treasurer, Lester S. Kellogg.

The Secretary reported that he had received no nominations by petition. The nominees proposed by the Nominating Committee were elected unanimously.

Willard L. Thorp accepted the chair as President of the Association for 1947, after which the meeting was adjourned.

LESTER S. KELLOGG, *Secretary*

Report of the Board of Directors

Again this year, we have met in annual meetings with the other social science Associations although we still have not returned to our pre-war practice of planning programs jointly. We expect that the program committee for this year will start to function early enough so that the meetings next December will be well integrated.

The American Economic Association and the AAAS have already committed themselves to holding their annual meetings in Chicago during Christmas week in 1947. Several other societies, including the Econometric Society, expect to meet there at the same time. In view of our close relationship to these Associations, we have decided to plan our meeting for the same time and place.

In addition to our regular Annual Meetings we held a number of sessions with Section K of the American Association for the Advancement of Science in St. Louis in March, 1946. The program included papers on Quality Control, Sampling, and Design of Experiments.

Stuart Rice, Chairman of the Arrangements Committee for the 25th Session of the International Statistical Institute, to be held in Washington, D. C., in September 1947, has invited our Association to plan some sessions simultaneous with those of the Institute.

The 25th session of the ISI was originally scheduled to convene in the United States on the occasion of the Centenary of the ASA in 1939. The 1935 joint resolution of Congress, which authorized the President of the United States to invite foreign countries to send official representatives to the session, specifically referred to the Association's Centenary as the occasion for holding the Institute session in this country. The war intervened to defer the Institute gathering until this coming year, and the Association felt that it would be particularly appropriate to accept Dr. Rice's invitation to be one of the host societies, and to participate in making the ISI sessions a World Statistical Congress.

The Statistical and Population Commissions of the United Nations have recommended to the Economic and Social Council that the Council plan a number of sessions in conjunction with the other meetings; the purpose of their sessions would be to focus attention upon the statistical activities of the United Nations and the specialized agencies.

The Association, itself, has undertaken to plan several sessions dealing primarily with the development of statistical sampling and institutional statistics in the United States and has assumed responsibility for the preparation of a display of graphic materials.

The Association program committee for the World Statistical Congress is: Willard L. Thorp, *Chairman*, Philip M. Hauser, Jacob Marschak, Aryness Joy Wickens, Jerzy Neyman, and George W. Snedecor.

The discussions of the need for a committee to establish standards of professional practice in the statistical field bore fruit this year in the appointment of a temporary committee to draw up recommendations concerning a standing committee of the Association which would be a permanent part of the organizational pattern of the ASA. The report of this committee was presented at the annual business meeting with the recommendation of the Board that it be accepted and that a permanent committee be appointed during the coming year.

A number of Journal exchanges with European countries have been reestablished during the past year, and a number of gifts of Journals to universities and libraries have been made. We are again in communication with some of our mem-

bers in Italy, Central Europe, the USSR, China, and Japan, and we hope that the World Statistical Congress, next September, will make it possible for us to obtain more information concerning their activities during the war years.

The Association received this year a formal invitation to become an affiliated member of the Inter American Statistical Institute. The IASI was created with the broad objective of fostering statistical development in American nations, and so far has directed its resources and energies toward aiding in the improvement of the methods used in the general bureaus of statistics throughout the American republics.

The Association has had an exchange relationship with the Inter American Statistical Institute since its foundation, and had participated in some of its activities on an informal basis from its beginning. The invitation to affiliate was accepted, and the ASA is now a member of the Institute.

The Biometrics Section of the ASA met with the American Association for the Advancement of Science in St. Louis on March 27–30, 1946 and also held six sessions in conjunction with the Boston meeting of the AAAS, December 26–31, 1946. At the Boston meeting there were two sessions of contributed papers and other sessions held jointly with the Atlantic Fishery Biologists and the Institute of Mathematical Statistics.

At the end of its second year of publication the *Biometrics Bulletin* had 1,150 members and 150 library subscribers. The success of the Bulletin in the two years of its existence and the number of articles being submitted for publication prompted the Editorial Committee to change to a quarterly instead of a bimonthly publication, and to change the name of the periodical from *Biometrics Bulletin* to *Biometrics*. It is expected that within the next year or so, subscriptions and the flow of manuscripts will have increased sufficiently to make it possible for the Section to maintain a publication of Journal size and standards.

Abner Hurwitz and Floyd C. Mann of the Bureau of Labor Statistics, prepared an analysis of the ASA membership which was printed in the June issue of the JOURNAL. The analysis indicated that our membership is still drawn preponderantly from the field of economics, and that the largest single group belonging to other societies was affiliated with the American Economic Association. The analysis gives detailed information on the type of work engaged in and the special interests of Association members. This analysis is a useful guide in planning publications and further activities of the Association.

Activities of chapters have increased greatly during the past year. With the end of the war, the chapters in Atlanta, Georgia, and Harrisburg, Pennsylvania, have been revived. A group of members in Ithaca, New York, has petitioned the Board for a charter for a new chapter, and additional chapters are expected from many other parts of the country during the coming year.

The number of articles submitted to the JOURNAL during the past year has increased greatly, and the statistical quality of the articles received has improved. In fact, the number of good papers received prompted the Directors to bring out a greatly enlarged issue of the December JOURNAL to absorb the backlog of accepted articles, and to propose that the JOURNAL carry an increased number of articles during 1947.

The review section of the JOURNAL and the Statistical Methodology Index, which was started with the September 1945 issue, have continued to grow. New publications have been reviewed very promptly during the past year, and a new

feature of multiple reviews of important books, letters about books, reviews of statistical periodicals, of book length articles, and books on mathematics which are useful to statisticians has been introduced. The Statistical Methodology Index has carried almost a thousand references, from well over a hundred periodicals, and has expanded to the point where the Board feels that it is suitable material for a separate reviewing and bibliographic JOURNAL. The Secretary has been asked to explore the possibility of bringing it out as a separate publication of the Association.

We have approved plans for revising the *ASA Bulletin* in order to make it more definitely a professional news publication suitable for distribution to members of associated and affiliated societies as well as to make it more useful to our own members. In the coming year, it is planned to shift from quarterly to bi-monthly publication, to enlarge the size, and to change the name.

The sessions on acceptance sampling which were held on January 27, 1946 in Cleveland, under the chairmanship of John Tukey, are to be printed some time this year, as a special publication of the Association. A group of papers on probability, written by Bortkiewicz, Lexis and Markov, will be printed if sufficient subscriptions are received.

The Committee to Advise the Bureau of the Census, The Committee on Census Enumeration Areas, and the Committee to Advise the Bureau of Labor Statistics on its employment statistics program have continued to render valuable service this year.

The Committee on Structure prepared a draft of the Constitution for the Association which was printed and distributed at this annual meeting. A final revision will be prepared so that a final mail vote of the membership may be taken.

The AAAS which has been actively supporting national science foundation legislation, asked the Association to appoint representatives to the Inter-Society Committee on Science Foundation Legislation. President Lubin appointed Willard L. Thorp and Frederick F. Stephan to represent the Association in support of such legislation.

The Committee on Preservation and Destruction of War Records completed its activities and was dismissed with thanks by the Directors.

We have been asked to establish a number of new committees this year, notably a Committee to Advise the National Housing Agency on Statistical Problems, a Committee on Education and Training of Statisticians, and a Committee on Graphics.

With the return of many veterans to civilian life, it was found that the national office of the Association was unable to handle the number of requests for information on placement in statistical positions which were being received. The Secretary's office obtained the cooperation of Paul Peach of the Institute of Statistics of North Carolina, who agreed to maintain a clearing house of placement information in the statistical field for the Association.

CHESTER I. BLISS
E. GROSVENOR PLOWMAN
WALTER A. SHEWHART
SAMUEL A. STOUFFER
WILLARD L. THORP
HELEN M. WALKER

The Secretary's Report on Membership

During 1946, membership in the American Statistical Association increased by 363, bringing the total on December 31, 1946 to 3,843. The continued growth during the past year indicates the growing interest in the Association's activities and indicates clearly a large, untouched, potential membership.

The 1946 membership is composed of the following groups:

Honorary members	15
Fellows*	127
Regular members	3,701
Total Membership	3,843
Corporate members	3

There were 58 resignations in the course of the year and 209 members were removed from the rolls for failure to pay dues.

Morris A. Copeland, D. J. Finney, Lowell J. Reed, and Philip Cortney were elected to Life Membership during 1946, bringing the total Life Members to 51.

The deaths of the following members were recorded during the year: Leonard P. Ayres, Victor S. Clark, A. R. Crathorne, John H. Gray, Frederick L. Hoffman, and Carl Snyder—*Fellows;* Alexander Andrews, Margaret J. Dix, Thomas J. Duffield, Corrington Gill, Thomas Haslam, Forrest R. Immer, Solomon Kuznets, Eliot G. Mears, Harry Mehlman, Rolf Nugent, Corliss L. Parry, and Walter Schilling—*Regular Members.*

LESTER S. KELLOGG, *Secretary*

* This figure does not include the nine Fellows elected at the Annual Meeting in January, 1947

Report of the Treasurer

The 1946 budget as approved by the Board of Directors planned for an income of $26,995 and expenditure of $29,595. At the end of the year actual income was $29,213 and our expenditures came to $29,558. This deficit of only $345 is considerably less than the planned deficit of almost $2,500, partly because of the difficulty of finding adequate help in a period of labor scarcity.

The increase in income has come largely from new memberships, increases in subscriptions and additional advertising in the JOURNAL, and was substantial enough to permit the publication of a greatly enlarged December issue of the JOURNAL. Income from the *Biometrics Bulletin* has increased, and it is expected that its income for the next few years will continue to expand as its service becomes more widely recognized.

The national office is planning a new drive for memberships and subscriptions this year and the budget will consequently be substantially increased.

LESTER S. KELLOGG, *Treasurer*

Report of the Auditors

To the Board of Directors of
American Statistical Association

We have examined the attached financial statements of American Statistical Association relating to the year ending December 31, 1946. Our examination was made in accordance with generally accepted auditing standards applicable in the circumstances, and included such tests of the accounting records and other supporting evidence and such other procedures as we considered necessary.

The recorded cash receipts for the year were traced to the deposits shown on the bank statements and the amounts for dues and subscriptions were tested with the membership and subscription records. The paid checks and relative vouchers were inspected in support of the cash disbursements for the year. The bank balances were reconciled with certificates obtained direct from the depositaries and the cash on hand and the securities owned at December 31, 1946 were verified by inspection. We did not check the membership and subscription records in detail or make any independent verification of the inventory of old JOURNALS, the office records of which are based, in part, on data assembled in prior years, no recent physical inventory having been taken.

The life membership reserve is computed on the basis of the combined annuity table of mortality with assumed interest at 4% per annum and an assumed annuity of $5.00 per life member, in accordance with a resolution of the Board of Directors on March 31, 1936. The amount treated as income in each year represents the excess of the reserve at the beginning of the year plus interest for the year and new life membership receipts over the required reserve at the end of the year.

In our opinion, the accompanying statements present fairly the position of American Statistical Association at December 31, 1946 and the results of its operations for the year, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

PRICE, WATERHOUSE & Co.

AMERICAN STATISTICAL ASSOCIATION

BALANCE SHEET

	December 31, 1946	December 31, 1945
Assets		
Cash in bank and on hand	$12,475.91	$11,383.58
Accounts receivable	774.19	80.04
Investments:		
United States Savings Bonds, Series D, at redemption value	5,910.00	5,749.00
Stocks, at cost (at market quotations $6,358 and $6,875, respectively)	5,793.50	5,793.50
Inventory of old JOURNALS, at approximate cost	2,158.04	1,807.56
Furniture and fixtures, at cost less depreciation	847.11	828.20
	$27,958.75	$25,641.88
Liabilities		
Accounts payable	$ 3,537.45	$ 1,772.07
Deferred income (collections applicable to subsequent year):		
Dues	$ 7,260.67	$ 6,570.00
Subscriptions	3,158.48	3,064.85
JOURNAL advertising		183.76
	$10,419.15	$ 9,818.61
Net worth:		
Life membership reserve	$ 3,377.35	$ 3,201.75
Centenary Sustaining Fund, per statement	6,376.01	6,255.25
Surplus, per statement	4,248.79	4,594.20
	$14,002.15	$14,051.20
	$27,958.75	$25,641.88

American Statistical Association

Surplus Statement

	Year ending December 31, 1946	1945
Balance at beginning of year	$4,594.20	$6,116.02
Deduct—Excess of expenses over income for the year, per income statement	345.41	1,521.82
Balance at end of year	$4,248.79	$4,594.20

Centenary Sustaining Fund

Balance at beginning of year	$6,255.25	$6,114.21
Add—Amounts received from contributors on pledges	$ 10.00	$ 30.00
Interest received on bank savings account and increase in redemption value of securities	106.76	106.54
Net proceeds from sales of Index to the Journal	4.00	4.50
	$ 120.76	$ 141.04
Balance at end of year	$6,376.01	$6,255.25

American Statistical Association

Income Statement

	Year ending December 31, 1946	1945
Income:		
Dues—current year	$17,452.50	$15,419.50
Dues—prior years	92.00	101.75
Life memberships	352.47	317.67
Subscriptions	5,341.30	4,588.91
Advertising	1,700.88	897.86
Reprints	530.93	479.23
Journal sales	793.80	647.35
Biometrics Section income	2,121.97	1,587.83
Miscellaneous	394.71	103.16
Dividends and interest (after deducting $128.07 in 1946 apportioned to life membership reserve)	432.08	277.11
	$29,212.64	$24,420.37
Expenses:		
Journal—printing, mailing and reprints	$ 7,908.35	$ 6,074.92
Bulletin	991.01	717.02
Salaries and wages	11,876.44	12,157.14
Unemployment compensation tax	11.20	11.37
Rent	1,020.00	1,020.00
Office supplies, printing and mimeographing	1,277.44	1,285.93
Postage	1,060.07	871.39
Telephone and telegraph	369.30	247.44
Travel expense—officers	287.29	276.72
Biometrics Section expenses	2,185.81	2,570.49
Membership Directory expense	1,575.76	
Storage of old Journals	72.00	72.00
Cost of Journals sold	58.69	62.16
Depreciation of furniture and equipment	149.49	146.15
Annual meeting expense (net)	238.84	13.31
Miscellaneous	476.36	416.15
	$29,558.05	$25,942.19
Balance, loss, carried to surplus	$ (345.41)	$(1,521.82)

COMMITTEE REPORTS

The Biometrics Section. The Editorial Committee has made several changes in the publication of the Biometrics Section. Beginning with the first issue of 1947, the *Biometrics Bulletin*, which has appeared bi-monthly during 1945 and 1946, will be published quarterly under the title *Biometrics*. The articles will be printed in one column instead of two, and larger type will be used. No change of the total number of pages per volume is planned at this time, but it is expected that the number of articles offered for publication will soon be large enough to warrant the establishment of a Biometrics Journal.

The Biometrics Section took part in the Annual Meeting of The American Statistical Association in January, where it sponsored one session of contributed papers and one session jointly with The Institute of Mathematical Statistics and The Econometrics Society. At the meetings of the American Association for the Advancement of Science, the Section participated in six sessions, one jointly with the Atlantic Fisheries Biologists, one with the Ecological Society of America, two with the Institute of Mathematical Statistics and two devoted to contributed papers.

The membership in the Biometrics Section, at the end of December, 1946, was made up of 207 associate members, 943 members of both the A. S. A. and the Section, with 150 additional subscribers to the *Biometrics Bulletin*. This represents a small increase in membership during 1946.

Census Advisory Committee. The Census Advisory Committee of the American Statistical Association met twice during 1946, once in June and again in November, each time for two days. It continued its review of Census programs and its discussion of Census policies with the view toward advising the Director of the Bureau of the Census on program.

One of the important discussions during these meetings involved the dangers arising from undue cuts of governmental budgets resulting from the economy drive in Congress and their effect on important statistical series. There is danger that in the course of reducing governmental expenditure, important statistical work may be affected. A possibility of forced retrenchment of this type may lead to a re-examination of relationships between agencies, to the elimination of any possible duplication both in fact and principle, and to other steps designed to make the statistical work of the government more meaningful and more defensible from the budget viewpoint. Since this problem is not limited to the Bureau of the Census, it is possible that this topic may be a subject for the Association to consider as a separate part of its activities.

At the last session of Congress, a bill (H.R. 5857) was introduced which would have placed the Census of Manufactures, including Mineral Industries, and the Census of Business on a quinquennial basis in the years 1952 and every fifth year thereafter. The current program of the Bureau would also have been strengthened by this bill. This legislation was in line with the recommendations of the Advisory Committee in the past. However, this proposed legislation was not enacted and the Committee understands that similar legislation is to be introduced at the 80th Congress. It is the Committee's feeling that a program such as that called for by this legislation would be a considerable step forward in establishing a more adequate statistical program.

The Committee has watched with considerable interest the development of an improved field organization in the Bureau. The field staff, while primarily engaged in the enumeration work for the Monthly Report on the Labor Force and the current business statistics program, has great possibilities, not only as the nucleus for the field organization of major censuses, but also for conducting surveys for other Federal agencies which do not have such an organization.

The Committee discussed at its June meeting the tentative plans for an annual sample survey of agriculture. Consideration of such a survey arose from the plans for an annual sample census of population which had been advocated as part of the Bureau's program. After considerable discussion the Advisory Committee passed a resolution recommending that this proposal be investigated further. The resolution is attached at the end of this report.

At the November meeting the principal subject for discussion was the 1947 Census of Manufactures. This Census is authorized by law and the Bureau has requested funds for it in the 1948 budget. The Committee reviewed the procedures for submitting these proposed questionnaires to industry so that the best possible clearance could be obtained. It also discussed a number of problems in connection with this census, such as the effects of intracompany transfers and shifts among the industries in regions over periods of time; the problems of maintaining the confidential status of the operation of individual companies; and the relationship of Census Statistics on Manufacturing to reports to the Social Security Board, the Bureau of Internal Revenue, and other agencies. One of the interesting developments in connection with this Census is the pressure which is coming from several sources to include questions on transportation on the schedule for this Census and even to conduct a separate Census of Transportation. The problems involved are being reviewed by a committee of the Budget Bureau which has been considering the entire subject, inasmuch as other agencies, such as the Bureau of Public Roads, the Interstate Commerce Commission, the Department of Agriculture, the Bureau of Foreign and Domestic Commerce, as well as nongovernmental agencies, are interested. In general, the Advisory Committee felt that this problem called for considerable investigation before any definite plans could be made. The possibility of individual studies to be integrated by a single agency was mentioned.

At a number of points in its discussions, the problem of reporting areas such as metropolitan districts and Census tracts were mentioned. Since the plan for the next few meetings calls for a review of the program for the Seventeenth Decennial Census (1950), it was decided to begin with a review of the geographic work of the Census which will deal with this problem further.

Throughout the meetings during the past year the Census Advisory Committee has emphasized the need for analysis and research in the Bureau's program. It is pleased to note that some steps have been taken in this direction. A number of suggestions were made for extending this type of work further. Another point which came up a number of times and which requires further study is a more detailed analysis of users of Census data. This problem is particularly difficult because of the general nature of the reports of the Bureau and their widespread use.

W. F. Ogburn, *Chairman*

RESOLUTION on Census Annual Sample Survey of Agriculture Adopted by the Census Advisory Committee of the American Statistical Association, June 21, 1946.

The advisory committee is strongly of the opinion that the plans for an annual sample survey of population should include provision for a supplemental schedule of questions on agriculture in the rural areas. The agricultural schedule should be so planned as to provide information on a number of important general aspects of agriculture which cannot be included in the regular decennial and quinquennial censuses and for which a well-planned sample will provide reasonably adequate information. Such things as tenure, indebtedness, home equipment, and related social and economic problems are well suited to this form of inquiry.

By rotating the questions from year to year, many of the questions long urged by users of census data but omitted for lack of space could be covered, and the excessive number of questions now carried on the decennial census of agriculture could be reduced, thus improving the basis data on crops, livestock, and land-use which constitutes the main body of the decennial Census of Agriculture.

The initiation of such a sample survey of agriculture should, in the opinions of the Advisory Committee, be preceded by a written memorandum of understanding with the Department of Agriculture outlining in principle an agreed division of labor between the two agencies as to types of data that will be gathered by each of the two by means of the different sampling methods used. The sampling procedure used by the Department of Agriculture consists mainly of mailed inquiries designed to provide quick, current estimates on crop conditions, changes in numbers of livestock and so on. There appears to be an excellent basis for a coordinated division of labor that will be acceptable to both agencies and will both provide additional information not now available and relieve congestion in decennial and quinquennial schedules.

Committee on Census Enumeration Areas. A meeting of the Committee on Census Enumeration Areas of the American Statistical Association was held on Saturday, January 25, 1947, at the Chalfonte-Haddon Hall in Atlantic City.

A total of 37 members of the committee, representatives of census tract cities, and guests were present.

Papers were presented by Leon E. Truesdell, Chief Population Division, Bureau of the Census, on "Retrospect and Prospect" and by C. E. Batschelet, Chief Geography Division, Bureau of the Census, on "The Creation of Census Tracts in Metropolitan Districts."

Reports were given for the following census tract areas: Baltimore, Cincinnati, Cleveland, Hartford, Jersey City, Los Angeles, Milwaukee, New York City, Philadelphia, Portland, Ore., St. Louis, St. Paul, San Francisco, Syracuse, Trenton, and Canada. A sound motion picture on the use of census tracts was shown by Mr. Guy E. Marion, Census Tract Key Person for Los Angeles. The Chairman gave a review of the work of the Committee during the past year.

Copies of a new Census Tract Manual, prepared by Leon E. Truesdell, Howard Whipple Green, and Esther M. Wright, were distributed and discussed.

* * * * *

A complete set of the papers presented at the January 25, 1946, meeting of the

Committee was sent following the meeting to all Key Persons and others interested in census tract use.

"Open houses," to exhibit census tract materials were held in Cleveland at the office of the Chairman, in connection with the American Statistical Association meetings in January, the American Sociological Society convention in March, and the American Public Health Association meetings in November. The Chairman also presented papers on the use of census tracts at each of these national meetings.

A special exhibit was arranged for the American Public Health Association meetings in Cleveland. One panel of the exhibit was prepared by Dr. W. Thurber Fales, Director of the Statistical Section, Baltimore, City Health Department, and showed, in a very interesting and graphic manner, how census tracts are used by the Baltimore Health Department in processing birth certificates and aiding in the diphtheria immunization program. The other panel, prepared by the Chairman, illustrated how census tracts may be combined into economic tenths to discover areas in which public health efforts must be concentrated. The booth was covered by Miss Lillian Guralnick of the National Office of Vital Statistics, Mr. Green, and members of his staff. There were many inquiries from visitors about census tracts and their application to public health work.

Considerable interest is beginning to be shown in the 1950 census, and more and more cities are working on plans for laying out census tracts in areas surrounding the census tract cities.

Dr. Lemieux of Ottawa reports "that the concept of Census Tracts is rather new in Canada and it is only in the last few years that, after studying various reports published by the United States Bureau of the Census, requests came to have similar divisions made for our Canadian cities.

"Before the 1941 Census we had been able to subdivide the cities of Vancouver and Winnipeg and a bulletin giving information by Census Tracts for those two cities was issued shortly after the taking of the census. Between 1941 and 1946, the cities of Calgary, Edmonton, Regina and Saskatoon were subdivided into tracts and the Quinquennial Census of 1946 will provide certain information according to these subdivisions. It is also hoped that between now and 1951, tract figures will be available for the cities of Montreal, Quebec, Toronto, Hamilton, Windsor, and Halifax."

The Committee wishes to express its appreciation to the Bureau of the Census for its cooperation during the year. Members of the consulting staff of the Vital Statistics Division, before being transferred from the Bureau of the Census to the Federal Security Agency, made surveys of census tract use in a number of cities as well as giving the Chairman assistance in his committee work.

Respectfully submitted,

HOWARD WHIPPLE GREEN, *Chairman*
C. E. BATSCHELET
W. THURBER FALES
ERNEST M. FISHER
SHIRLEY K. HART
PHILIP M. HAUSER
O. A. LEMIEUX
VERGIL D. REED
LEON E. TRUESDELL
LENT D. UPSON

The Joint Committee on Occupational Classification of the American Statistical Association and the Division of Statistical Standards of the Bureau of the Budget has a continuing responsibility for resolving differences of treatment in occupational titles and their content among the several government agencies collecting statistics by occupation. In this connection, it has also undertaken to adapt the Standard Industry Code, which was developed for classifying reports from business establishments, to the special problems of reports from individuals, as in a population census.

Changes in industrial technology and in the arts and sciences constantly give rise to new occupations and industries and to the professionalizing of occupations in particular services to the community. Account of these changes has to be taken in the occupational classifications in use by government agencies if meaningful statistics are to be available. At the same time, the maximum degree of comparability between past, present, and future statistics is also desirable, since the trends in employment by occupation or industry or in wages by occupation or industry are important aspects of economic analysis. The Committee has taken the general position that new occupational or industrial titles could be incorporated as occasion arose, after clearance with the Committee, but that proposed changes in the content of titles in use or changes which cross group lines, such as a change from the clerical to the professional group, were to be incorporated infrequently. In fact, proposed changes of the latter type were postponed for consideration until such time as major revisions in codes could be reviewed. This time has now arrived since the Bureau of the Census and the United States Employment Service are revising their respective occupational codes, and the Standard Industry Classification is also being revised. All types of proposed changes are, therefore, now before the Committee for consideration.

The work of the Joint Committee and its Technical Sub-committee involves resolving, on a standard basis, any differences which may develop in the revisions of the United States Employment Service's Dictionary of Occupational Titles and the Occupational Code structure of the Bureau of the Census. The Committee is now reviewing all professional and semi-professional occupational titles in use by government agencies which collect occupational statistics in relation to those in the Convertibility List. In the course of this work, consideration is given to the requests of private professional or occupational associations to government agencies for different treatment of specific titles in their respective occupational classificational structures. All proposed changes have to be reviewed in the light of technical problems in the reporting of occupational information, the heterogeneity or homogeneity of the statistics which would be obtained as a result of changes in the content of specific occupational groups, and the effects of such changes on the Convertibility List and the more detailed systems of the Bureau of the Census and the United States Employment Service. Subsequent work of the Committee will cover other major occupational groups and any modifications required in industry codes.

GLADYS L. PALMER, *Chairman*

Committee on the Employment Statistics Program of the Bureau of Labor Statistics. This Committee was established by the Association in May, 1945, at the request of the Secretary of Labor, to review the proposed expanded employment statistics program of the Bureau of Labor Statistics. The mandate of the Com-

mittee is limited to the Department of Labor and to current statistics as distinguished from conjectural forecasts.

During the past year the Committee has examined many documents pertaining to sampling, benchmarks and other procedures for obtaining estimates of nonagricultural employment being used by the Bureau of Labor Statistics. Members of the Committee have continued with conferences and discussions with officials and technical experts of the Bureau of Labor Statistics and other government agencies concerned with employment.

At present the Committee is working on a final revision of its report which it hopes to submit within a few weeks.

W. A. BERRIDGE
R. W. BURGESS
O. A. FRIED
M. I. GERSHENSON
S. S. WILKS, *Chairman*

The Committee for the Preparation of a Source Book of Economic Statistics. This committee has been working with the Bureau of the Census and a representative group from the Social Science Research Council in the preparation of the Source Book of Historical Statistics.

The volume, to be issued as a special supplement to the *Statistical Abstract*, is a collection of historical statistics portraying the economic growth and political and social history of the United States from 1789 to the present. It will contain about 1,000 pages, equally divided between text and statistics. About 2,500 to 3,000 selected series of data will be presented, together with definitions of terms and comparisons of series. Text material will describe only the statistical significance of the data. Most of the information will relate to the continental U. S. as a whole, rather than to states or localities.

The preliminary list of chapters includes: Summary Measures of American Development—population movements, labor force shifts, industrial techniques, economic organization, national income and product, national wealth and standard of living, production and prices; Land and Climate; Population and Vital Statistics; Social Institutions and Activities; The Labor Force, Wages and Working Conditions; Extractive Industries; Construction; Manufacturing; Transportation; Communication and Power; Domestic Trade; International Trade and Finance; Banking and Finance; Governmental Activities; Consumption.

Three appendixes will cover (1) Statistics of the Colonial Period; (2) Business Cycle Turning Points and Selected Indicators; and (3) Bibliography on Methodological Techniques Commonly Employed in Analysis of Time Series.

Experts from Government, the academic world, and private research are being asked to help prepare and select the material. The advisory committee includes: J. Frederic Dewhurst, A. Benjamin Handler, Shepard B. Clough, Arthur H. Cole, Stacy May, Morris A. Copeland, Ernest Griffith, Edward Hutchinson, Walter Mitchell, Jr., Amos E. Taylor, and Harold F. Williamson.

Representative on the Board of the National Bureau of Economic Research. The chief event of the year was the celebration of the Twenty-fifth Anniversary of the National Bureau's foundation, a celebration deferred from 1945 because of wartime conditions. The work of the Bureau was discussed and appraised and the

role of economic research in the development of economic science and public policy was explored in a two-day meeting held at the Waldorf-Astoria Hotel in June 1946. Papers presented by distinguished scholars from the United States and other countries to an audience of several hundred economists and other social scientists have been published in a volume *Economic Research and the Development of Economic Science and Public Policy.*

The distinguished leadership of Wesley C. Mitchell during the first twenty-five years of the National Bureau's existence was recognized and lauded by the speakers from abroad and by representatives of research organizations and learned societies in the United States.

The Twenty-fifth Anniversary is to be further commemorated by a series of seven monographs now published or in process of publication.

Arthur F. Burns, Director of Research, devoted the twenty-sixth annual report of the National Bureau, published in June 1946, to a notable discussion of *Economic Research and the Keynesian Thinking of Our Times.*

Other publications have been issued during the year.

In addition to the publications and continuing investigations of the National Bureau in fields that have been cultivated in the past, an investigation of experience with corporate bonds as investments was launched in August 1946 under the direction of W. Braddock Hickman. In this study records of corporate bond issues in the United States during the period since 1900 will be analyzed.

List of Committees and Representatives for 1946

Committee on Fellows

Lowell J. Reed, *Chairman*
Aryness Joy Wickens, *Acting Chairman*
Henry B. Arthur
Joseph S. Davis
Harold Hotelling

Committee on Nominations

Frederick F. Stephan, *Chairman*
Winfield Riefler
Helen M. Walker

Budget and Investment Committee of the Board of Directors

E. Grosvenor Plowman
Walter A. Shewhart
Willard L. Thorp

Annual Meeting Program Committee

Isador Lubin, *Chairman*
F. L. Carmichael
Daniel B. DeLury
Samuel S. Wilks

Subcommittee In Charge of Graphic Display

John D. Witten, *Chairman*
Harry Dreiser
Kenneth Haemer
Margaret Martin
Mary E. Spear

Chairman, Local Arrangements

Edward Bloom

Biometrics Section Committee

D. B. DeLury, *Chairman*
H. W. Norton, *Secretary*
E. J. deBeer
A. E. Brandt
J. W. Fertig
J. G. Osborne
J. W. Tukey

Biometrics Bulletin Editorial Committee

Gertrude Cox, *Chairman*
R. L. Anderson
C. I. Bliss
W. G. Cochran
Churchill Eisenhart
H. W. Norton
G. W. Snedecor
C. P. Winsor

Census Advisory Committee

W. F. Ogburn, *Chairman*
Murray R. Benedict
Donald R. G. Cowan
J. Frederic Dewhurst
Luther Gulick
Frederick F. Stephan
Willard L. Thorp

Committee on Census Enumeration Areas

Howard W. Green, *Chairman*
Clarence E. Batschelet
W. Thurber Fales
Ernest M. Fisher
Shirley K. Hart
Philip M. Hauser
O. A. Lemieux
Vergil D. Reed
Leon E. Truesdell
Lent D. Upson

Joint Committee on Occupational Classification

Gladys L. Palmer, *Chairman* and *Secretary*
Meredith B. Givens
Carl Heinz
Ida C. Merriam
Robert J. Myers
Leon E. Truesdell

Advisory Committee to the Bureau of Labor Statistics on Employment and Statistics Program

S. S. Wilks, *Chairman*
W. A. Berridge
Robert Burgess
O. A. Fried
M. I. Gershenson

Committee on the Preservation and Destruction of War Records

Lester S. Kellogg
Morris A. Copeland
William R. Leonard
Aryness Joy Wickens

Representatives on the Committee for the Preparation of a Source Book of Economic Statistics

J. Frederic Dewhurst
Walter Mitchell, Jr.

Committee on Structure

Willard L. Thorp, *Chairman*
C. I. Bliss
W. G. Cochran
F. Leslie Hayford
Frederick F. Stephan
Helen M. Walker

Representative on the Board of Directors of the National Bureau of Economic Research

Frederick C. Mills

Members of the Social Science Research Council

Joseph S. Davis
Harold Hotelling
Willard L. Thorp

Representative on the Council of the American Association for the Advancement of Science

Walter A. Shewhart

Representatives on the Joint Committee for the Development of Statistical Applications in Engineering and Manufacturing

Churchill Eisenhart
Walter A. Shewhart

Representative on the Sectional Committee on Standards for Graphic Presentation of the American Standards Association sponsored by the American Society of Mechanical Engineers

Frederick E. Croxton

Representative on the Advisory Board of the American Year Book

Frank W. Notestein

Representative on the Advisory Committee to the Census Library Project

Irene Taeuber

Member of the American Documentation Institute

Lester S. Kellogg

BOOK REVIEWS

Edited by
OSCAR KRISEN BUROS
Rutgers University

Report of the President's Committee on the Cost of Living. *William H. Davis*, Chairman. Washington 25, D. C.: Government Printing Office, [July 1946]. Pp. v, 423. $0.60. Paper. (Although the title page bears the date 1945, the report was published in July 1946.) *Two reviews follow:*

REVIEW BY T. BARNA
Lecturer in Statistics, London School of Economics
University of London

THE President's Committee was appointed in October 1943. It took over a year to report, and its report was not published until July 1946. This distance in time, coupled with the physical distance of the reviewer, makes it possible to look upon the acute and topical controversy of the period at the peak of the war with more detachment than was forthcoming at that time.

The report is in no accepted sense the report of a committee. It consists of a statement by the chairman, Mr. William H. Davis; two statements by the labor members, violently disagreeing with him; a statement by the industry members agreeing; and a number of reports, documents, and letters written by or on behalf of members of the committee or by independent experts. A number of other documents, which are equally relevant, have been independently published and are not included.

Between January 1941 and December 1943 the BLS cost of living index rose by 23.4 per cent. The labor members maintained that the cost of living rose in fact by 43.5 per cent. Experts, the Mills Committee, and later the Mitchell Committee made a painful examination of all the relevant facts and vindicated the techniques and results of the BLS, and their opinion was accepted by Mr. Davis. In the reviewer's opinion no independent expert can fail to be impressed by the objectivity and technical efficiency with which the BLS index is prepared and by the fact that the index is appropriate for the purposes for which it was originally intended.

There seems to be a fundamental controversy about the meaning of the term "cost of living." The index is now called by a different name, and it is certain that it always intended to measure changes in average prices as they affect urban workers, that is, the cost of maintaining a constant standard of living. The index should not be influenced by changes in the standard of living. Mr. Thomas, the CIO member, introduces a distinction between the manner and the standard of living. Changes in the manner of living, he argues, such as movement into congested war centers, should be taken into account in arriving at the correct figure. But most changes in the manner of living which he had in mind were induced by higher earnings and were the consequence of a higher standard of living. It seems correct to compute

the cost of living index as it is computed, when it is comparable with an index of wage rates, and to assume that differences in the manner of living should be, and in fact always are, reflected in differences in earnings. An index which takes into account changes in the manner of living would be comparable to an over-all average of family earnings and not to an index of wages.

Criticisms of the BLS index can be grouped under four headings: that the sample of commodities included is not representative, that the commodities are not properly identified, that prices are not properly measured, and that the pattern of expenditure implied by the index had become unrealistic under war conditions. Under the first heading, it was said that prices of commodities (especially food) not in the sample have risen more than the index, and that prices have risen more in small cities than in cities represented in the index. Of an additional 7.22 points claimed on this account, the Mitchell Committee accepted 0.30 points, on account of the faster rise of rents in small cities. Under the second heading, 6.93 points were claimed for quality deterioration, of which 1.46 to 2.69 points were accepted. Under the third heading, it was claimed that the decline of special sales and underreporting of prices should add another 2.33 points to the index. This was reduced by the Mitchell Committee to 0.68 to 0.92 points. Under the last heading, 3.62 points were claimed for the disappearance of cheap lines, but the Mitchell Committee found only 0.06 to 0.11 points.

The independent inquiry thus estimated that the index should have been $2\frac{1}{2}$ to 4 points (and not 20 points) higher. But most of this increase consists of estimates not sufficiently accurate to be incorporated in an official index. It also seems that, as conditions return to normal, the reasons for correcting the index would disappear. The arguments of the industry members enumerating factors offsetting this correction seem to be invalid. But there is no mention of the fact that the base date weighting (used in the BLS index) gives an upper limit to the theoretical index as against the lower limit given by current date weighting.

The Mitchell Committee's approach is an excellent interpretation of the theoretical requirements of a good index. The only difficulty arises under the last group of criticisms mentioned above. When commodities are rationed, in short supply, or disappear from the market, the BLS adopts the best procedure possible in practice by substituting other commodities or increasing the weight of other commodities. The principle of substitution is, however, on an objective basis and not on the subjective basis of index number theory. To obtain the true index, an addition should be made for the subjective loss to the consumer consequent on substitution.* Similar considerations apply to the fact that the Mitchell Committee did not correct the index for lower quality when higher quality goods were not available.

But the BLS produces a good index for practical purposes. This is so because an index satisfying the theoretical requirements has little meaning

* Cf. E. Rothbarth, "Measurement of Changes in Real Income under Conditions of Rationing," and N. Kaldor, "Rationing and the Cost of Living Index," *Review of Economic Studies*, 1941.

when the institutional framework of the economy undergoes changes, as it did in wartime. The reviewer believes that a cost of living index is a good tool for short-period wage adjustments when prices change. But, in addition to wage adjustments caused by price changes, there are wage adjustments justified by changes in productivity or necessitated by changes in the framework of the economy. During the war national consumption had to be cut; hence, the primary aim of the index, to indicate income adjustments giving a constant standard of living, was a fortiori defeated. The problem of how to distribute the national income remained, but it is questionable that the aims of labor could have been achieved through rigging wages to any index. It might have been better to find more direct methods, such as the shifting of taxes from wages to profits. Some of the difficulties in applying the cost of living index to wage bargaining were unique during the war; but similar difficulties would arise under full employment conditions in peacetime. If, for instance, the cost of living rises as a result of a better parity of farm and nonfarm incomes, which might be in the national interest, wages can keep pace with the cost of living only at the expense of industrial profits. If, however, industrial prices are raised as a result of wage increases, the circle starts again. That is, it might be better to concentrate on real than on money incomes and to use the BLS index as a measure of past history and not as a guide to present policy in wage bargaining. The question of wage policy under full employment was raised only by Mr. Meany, the AFL member.

It is a great pity that the report was written in the present form. It would seem to an outsider that the committee members never met for an hour and would not agree on the most obvious points. The criticism of the index involved important points, but in parts it rested on evident technical errors and exaggerations. It is not at all clear why it was necessary to throw all these errors and their refutation at the public instead of settling these questions privately. One example is an error in computation in the early version of a labor report which was later corrected but is nevertheless mentioned a good many times. Another example is the misunderstanding, even after a clear explanation, of the fact that the BLS index did include price quotations above the ceiling when such quotations were obtained. Instead of a series of documents, we would be much happier to possess a single document discussing all questions in a logical order, with perhaps dissenting notes added by some members. The report then would have been more convincing, more digestible, and very much shorter. The number of printer's errors could also have been reduced.

REVIEW BY H. G. LEWIS
Assistant Professor of Economics, University of Chicago

THIS document contains not only the report of the President's Committee (Davis Committee) but also almost all of the other technical reports, comments, appraisals, replies, and rejoinders involved in the government's answer to the AFL-CIO war-time attack on the "Little Steel" formula and

particularly on the underlying BLS cost of living index. The outstanding omission is the January 1944 report of the labor members of the Davis Committee (the Meany-Thomas report).

The contention of the labor organizations is well known. So also is the answer of the President's Committee: the BLS index, showing a 23.4 per cent increase from January 1941 to December 1943 may have underestimated the rise in the cost of living (for a typical urban wage earner family) by as much as 3 or 4 percentage points and surely by much less than the 20 percentage points alleged by the AFL and CIO. It is with this finding that this review will quarrel. This quarrel is significant to the reviewer not for any implication it may appear to have with respect to the wage control formula, but because of the significance attached to the BLS index in judging the effectiveness of war-time price control in stabilizing the cost of living. For if the report is substantially correct—and surely it will be accepted as correct by many, the price control program succeeded rather well in stabilizing the cost of living.

It is the contention of this review that the BLS index had a much larger downward bias as a cost of living index than the 3 or 4 points found by the Davis Committee. Three categories of evidence are offered in defense: (*a*) the reviewer's intuitive judgment, (*b*) indirect evidence obtained from estimates of consumer expenditures and consumption, and (*c*) appraisal of the evidence given by the Davis Committee and particularly its Technical Committee (Mitchell Committee).

The cost of living (index) increase experienced by the reviewer and derived from the behavior of his purse and from introspection on his level of real income (standard of living) is substantially greater than the increase shown by the BLS index. Friends and acquaintances affirm more often than they deny similar experiences. Furthermore, this apparently was also the experience of many in the labor organizations who attacked the index. Some readers may be disinclined to accept such introspection as evidence. Yet ultimately the true cost of living index is made of just such stuff.

The problem may be studied from another perspective—by examining price (of living) indexes implicit in time series on national consumer expenditures and apparent consumer physical consumption. Indeed, the AFL-CIO offered such evidence for examination by the Davis Committee. We may take, for example, the clothing category. The Mitchell Committee, using Department of Commerce expenditure estimates and Federal Reserve production estimates (adjusted by the Committee for inventory changes but not, it should be pointed out, for quality deterioration), found an implicit rise from 1941 to 1943 of 56.6 per cent in clothing prices in contrast to a rise of 21.8 per cent in the BLS clothing index. The difference between the two surely is startling, yet the Committee was of the opinion that the difference proved nothing about the BLS index. The Committee pointed out that the difference *might* be accounted for by: (*a*) errors in the series underlying the implicit index, (*b*) the fact that the implicit index referred to all families

while the BLS index referred only to typical urban wage earner families, and (*c*) voluntary uptrading contained in the implicit index. (Somewhat similar evidence for the food category was dismissed in much the same way by the Committee.) The errors in the underlying data of the implicit index, to be sure, may be substantial but not all in the direction of decreasing the index (taking account of quality deterioration would increase the index), and surely the errors cannot account for the major part of the difference. Moreover, the typical urban wage earner family is not a markedly atypical family. Finally, to imply that there was substantial uptrading and that little of this was forced by rationing (both formal and informal) is to imply that rationing did not force significant consumer substitution—that is, that price control was ineffective.

The BLS index may also be tested by the physical consumption indexes it implies. Department of Commerce estimates of consumer expenditures excluding military personnel abroad (*Survey of Current Business*, February 1946, p. 7) show a rise of 43 per cent from the first quarter of 1941 to the last quarter of 1944. Over the same period the BLS index rose approximately 26 per cent. The implication seems somewhat incredible: that national real consumption of consumer goods and services increased almost one-seventh during that war-time period.

Finally, some insight into possible bias in the index may be obtained from appraisal of the detailed analysis made by the Mitchell Committee. Differences between the reviewer and the Committee can only be highlighted so numerous are the individual details considered by the Committee. Particular attention is called to the Committee's handling of the problems of quality deterioration and forced uptrading.

The problem of accounting for quality deterioration was the most serious one considered by the Committee, and most of the three to four point error they found in the index was attributed to this factor. However, the reviewer believes the Committee underestimated the error on this score substantially because of two assumptions it made which appear invalid. First of all, the Committee made no correction for quality deterioration where lower quality could not easily be offset by the purchase of a larger number of units of the same or similar commodity or service. Thus no allowance was made for quality deterioration in housing, in the whole "miscellaneous" category, and presumably in other items for this reason. Surely this was a mistake. Poorer quality laundry service, for example, from a given laundry probably may not be offset by buying more units of service. But it may be offset by buying better laundry service from another laundry (a higher-priced one) or by making any of many less direct substitutions to maintain equal well-being. Poorer quality at the same or higher price, whether or not offset by purchase of more units, means a rise in the cost of maintaining the same standard of living.

In the second place, the Committee assumed (particularly for the clothing and house-furnishings categories) essentially that so long as a BLS specifica-

tion was unchanged the quality of the item priced was unchanged. In view of the necessary substantial breadth of the BLS specifications for the great majority of items priced and the general substantial decline in quality of clothing and house-furnishings particularly, the reviewer finds the Committee's assumption hard to swallow.

The Committee made no special correction for forced uptrading for any of the categories in the index, answering the AFL-CIO that the methods of the BLS recognized all significant costs attributable to this war-time factor. But the BLS recognized forced uptrading only for those items which disappeared from the market and were replaced *in the index* by higher-priced but similar items. No recognition of forced acceptance of more expensive substitutes (and all forced substitution is more expensive) was given where the item disappeared and was not replaced in the index. Furthermore, forced uptrading—forced acceptance of more expensive substitutes—occurs not only when an item disappears from the market but also when there is a shortage of supply at controlled prices.

Statistica. Published bimonthly by the Vereeniging voor Statistiek. Fl. 12.50 per year; fl. 2.50 per issue. Vol. 1, No. 1 published in 1946. Edited by *S. T. Bok, A. R. v. d. Burg, J. Sittig,* and *J. H. C. Lisman.* Editorial office: Blauwe Kamerlaan 19, Hague, Netherlands. Publisher: H. E. Stenfert Kroese Publishing Corp., Breestraat 14, Leiden, Netherlands.

REVIEW BY TJALLING C. KOOPMANS
Research Associate, Cowles Commission for Research in Economics
Associate Professor of Economics, University of Chicago

THIS is a new periodical, published by a new professional society, aiming at the propagation and development of statistics in the Netherlands. The point of view is not that of any particular field of application, but rather the discussion of statistical methods in a wide variety of scientific endeavors, of which the editorial introduction mentions in particular: industry and technology, economics and other social sciences, medicine, biology. The first issue contains an article about tolerance limits in the machine industry, an article describing the theory and practice of a mechanical apparatus for the statistical control of the weight of a packaged powder product, and an article describing an experiment in comparing accuracies of measurements carried out by six sampling inspectors. These articles reflect a first-hand experience of the situations in which quality control is applied. Another article criticizes the method applied by a popular magazine to measure the agreement between a recent election forecast based on a public opinion poll and the subsequent election results. An article in English reports on the developments in applied statistics in England during and after the war. Further articles on long-term weather forecasting, on telephone engineering, and on the connection between personality and the use of soporifics, are promised for the next issue. It is evident that the initiative

that produced this new publication has come from those actively engaged in the application of statistical methods in a wide variety of scientific and industrial activities.

How to Conduct Consumer and Opinion Research: The Sampling Survey in Operation. Edited by *Albert B. Blankenship* (Managing Director, National Analysts, Inc., Philadelphia). New York 16: Harper & Bros. (49 East 33rd St.), 1946. Pp. xiii, 314. $4.00.

REVIEW BY ROBERT FERBER
15 Broad Street, New York 5, New York

THE layman and the businessman, at whom this symposium is primarily directed, will find in this volume a wealth of simply written material on the application of sampling methods to consumer and industrial research. The book is divided into three main parts, "Surveys Reported to Business and Industry," "Surveys Reported to Government," and "Surveys Reported to the Public," preceded by an introductory chapter on sampling surveys by Dr. Blankenship. However, by far the greatest portion of the book—17 of the 23 chapters—is concentrated in the first part. In this part are to be found chapters on sampling as applied to product development, consumer and industrial research, copy testing, radio research, magazine readership, and personnel relations. Particularly good coverage is given to sampling in radio research, which is introduced by an excellent survey chapter on the subject by Paul F. Lazarsfeld and Marjorie Fiske. Succeeding chapters by A. H. Lehman and G. H. Allen, by C. E. Hooper, by S. Roslow and N. Kelly, and by S. G. Barton provide the layman with a very clear perspective of the various methods employed in radio research. A good deal of information on the application of sampling to various other phases of business research is to be obtained from the other chapters in part I. Worthy of particular mention for their clarity and good use of illustrative material are the chapters on product development by Percival White and Matilda White, on industrial research by C. E. Haring, on consumer purchases by S. G. Barton and by A. D. Freiberg, on copy testing by A. C. Welch and by A. D. Freiberg, and on readership by H. C. Ludeke and by Cornelius DuBois.

The four chapters in part II, dealing with sampling in government, describe in turn some of the sampling work of the OWI, of the Bureau of the Census, of the WPB, and of the Department of Agriculture. All together, they provide the layman with a good idea of the sort of sampling work which the government has been undertaking. The single chapter in part III, on public opinion research, by Wroe Alderson, contains an unusually lucid and informative survey of public opinion research as a whole and of the three top organizations in the field. The candid quality of this article as well as its excellent method of presentation renders it, in this reviewer's opinion, the most stimulating chapter in the book.

Although the individual chapters are, for the most part, clearly written and well presented, the organization of the book might perhaps have been

improved by preceding each group of chapters on a particular field with a general survey article outlining the types of sampling work being done in the field. For example, although the four chapters on sampling in government work provide good descriptions of the sampling work done by four distinct federal agencies, the reader gains no idea of the over-all sampling work of the government or of the different government agencies which engage in sampling work. A general descriptive and evaluative article on government sampling similar to Mr. Alderson's chapter on public opinion polls would have been very desirable.

As is perhaps natural in a symposium whose contributors are, by and large, representatives of private concerns, a fair amount of plugging one's own services does occur. Although this self-plugging does not extend to direct criticism of competitive concerns, it is nevertheless detrimental to competing organizations not represented in this book. In this sense it is particularly regrettable that Dr. Blankenship should have seen fit to say that "the present volume shows what organizations offer continuing (and fairly standardized) measurement services, so that the businessman will be able to get, from one source, the answer to his question on the various services available" (p. 2). This statement tends to discriminate against the many other competent sampling organizations in the field, a number of which also offer "continuing (and fairly standardized) measurement services."

From the technical viewpoint it is astonishing to discover how many of these top commercial researchers, who specialize in sampling, consider the ideal "quota" sample to be one where the size of the sample strata are proportional to the size of the strata in the population. Thus, "If, in a given locality, 85 per cent of the population is white and 15 per cent is colored, then the two groups should be represented in the same proportion in the sample" (p. 25). Nowhere in this book is any reference to be found on strata variability or on disproportionate sampling. In view of the extreme heterogeneity frequently found among strata variances, it is all the more surprising that proportional sampling continues to be employed in commercial research, even in most continuing studies where strata variances are readily ascertainable.

Despite the aforementioned shortcomings this symposium will provide interesting reading for those seeking information on the uses of the sampling questionnaire technique in commercial and public opinion research. Besides supplying a clear indication of the present status of sampling in commercial research the astute reader will observe examples of the more or less conflicting results claimed by competing organizations. For example, on the subject of radio research, one reads on page 172, "Actual breakdowns of audiences to many programs show significant differences in the listening habits of telephone and nontelephone groups" (Roslow and Kelly), and on page 187, "This limitation [of a radio mail panel to literate homes] has little effect on the volume of reported listening to most programs" (Barton). These statements are obviously contradictory to the extent that literacy and telephone

ownership are intercorrelated. If anything, however, such instances enhance the value of this book.

A Bibliography of Statistical Quality Control. *Grant I. Butterbaugh* (Associate Professor of Statistics, University of Washington). Published for the Bureau of Business Research of the College of Economics and Business, University of Washington. Seattle, Wash.: University of Washington Press, October 18, 1946. Pp. viii, 114. $1.50. Paper.

REVIEW BY PAUL C. CLIFFORD
Assistant Professor of Mathematics, State Teachers College
Montclair, New Jersey

A CASUAL glance through the Statistical Methodology Index of any recent issue of this JOURNAL will reveal the impressive number of articles being published on statistical quality control. Professor Butterbaugh has compiled a list of 712 articles, manuals, and books covering the period 1924 through 1945. This annotated bibliography is divided into three parts. Part 1 is devoted to articles that appeared in the periodical literature. The periodicals are listed alphabetically; under each periodical the articles are arranged consecutively according to date of publication. Some 76 manuals, monographs and pamphlets are listed by publishing agency in part 2. Seventeen books are listed in part 3. An index by authors indicates that approximately 340 different writers are represented.

The increase in interest in statistical quality control is shown by the date of publication of the articles. Approximately 90 per cent of the entries show a date in the 1940's. In view of this sudden growth in the field it is not surprising that no one definition of statistical control has received universal acceptance. One point of view is that statistical quality control means the use of standard control charts and acceptance tables by the inspection department. A broader point of view claims that statistical quality control means the application of statistical methods to all manufacturing problems including the determination of consumer wants, engineering research and design, specification, production, inspection, consumer satisfaction, etc. In addition, an article may emphasize either the engineering, statistical or management aspect of statistical quality control or any combination of these. Considering the difficulties of properly evaluating an article from all these viewpoints, Professor Butterbaugh has accomplished a herculean task in compiling this bibliography. Practically all the articles of interest to the inspector have been included. That the broad point of view has been considered is evidenced by eighteen articles from the *Annals of Mathematical Statistics*, thirteen from the *Journal of the Royal Statistical Society*, eighteen from the *Journal of the American Statistical Association*, etc.

It would obviously be impossible to include all the articles that might be of interest from the broad point of view. The reviewer would have been inclined to include a few more articles from the biological and chemical fields as well as several more from the *Proceedings of the American Society for*

Testing Materials. The notations on each article give the reader sufficient information about the content. The non-mathematician might wish that the level of mathematical difficulty were more clearly indicated.

The lack of a subject matter index may curtail the usefulness of the bibliography. Such a subject index would be difficult to make, since many of the articles during the war attempted to present the fundamental concepts of quality control with applications in several fields. In view of this difficulty the author's device of listing articles by periodicals is probably as useful as any. The engineer with interest in one specific field will thus be able to find the articles of most interest. The student of statistics looking for outstanding illustrations of the application of statistics to industrial problems will have more difficulty. The teacher of industrial statistics or statistical quality control should find the bibliography extremely useful.

Mathematical Methods of Statistics. *Harald Cramér* (Director, Institute of Mathematical Statistics, University of Stockholm). Uppsala, Sweden: Almqvist & Wiksells Boktryckeri-A.-B., 1945. Pp. xvi, 575. (Princeton, N. J.: Princeton University Press, 1946. $6.00.) *Two reviews follow:*

REVIEW BY PAUL G. HOEL
Associate Professor of Mathematics, University of California at Los Angeles

THIS excellent book will be welcomed by mathematicians who wish to become acquainted with statistical methods and, even more so, by statisticians who desire a reference book for proofs of many of the fundamental theorems of statistical theory. The large amount of material that it contains, which ordinarily is found only in more advanced books and journals, will particularly enhance its reference value. Although the principal appeal of this book will be for reference use because of the level at which it is written, nevertheless it is carefully organized and presents a systematic development of mathematical statistics.

The author states that the book is largely self-contained for students with a good working knowledge of calculus; however, many of the proofs will be found to require a background of at least advanced calculus or real variable theory for their understanding.

The book is divided into three distinct parts. Part I presents basic mathematical theory for later use; part II develops general and particular distribution theory; and part III applies the preceding material to the theory of statistical inference.

Part I will be particularly valuable to the statistician who has not had graduate courses in mathematics because it brings together much unrelated mathematics that is needed for an understanding of later proofs. Much of the material is devoted to a systematic development of properties of Borel sets and Lebesgue-Stieltjes integrals. This part includes proofs of the important uniqueness and continuity theorems, which are fundamental for

the method of characteristic functions, or moment generating functions. It also includes much helpful material on matrices and quadratic forms, such as the reduction of quadratic forms to diagonal form, Cochran's theorem, etc.

Part II begins with an interesting discussion of statistical stability and its relation to the author's choice of axioms of probability. This is followed by a large amount of material on general and particular distribution functions and their properties. Most of the derivations of particular distributions are fairly standard, although the t and z distributions were not derived as generally as might have been done. The feature of part II that particularly appealed to the reviewer was the extensive treatment of convergence theorems. Topics on convergence include Bernoulli's, DeMoivre's, and Khintchine's theorems; a central limit theorem for equal components and one for unequal components. This is the only one of the three parts for which exercises are available; most of the exercises are quite mathematical in nature.

Although part III contains many excellent sections on statistical inference, a number of important topics are not included. Many readers undoubtedly would have preferred less emphasis on part I and more on statistical inference; however, this is a matter of taste and would not as satisfactorily have accomplished the author's objective of presenting a rigorous, systematic, mathematical treatment of statistical theory. Part III begins with a discussion of random sampling and its relation to statistical inference. This is followed by material on moments, including unusual material on asymptotic distributions of functions of moments and of extreme values. Then exact sampling distributions are derived, including the Wishart, generalized variance, and generalized t distributions, in addition to the usual small sample distributions. The remaining material is devoted to the chi-square test, significance tests by means of standard errors and exact distributions, the general theory of testing hypotheses, analysis of variance, and regression theory. The section on estimation is one of the particularly interesting and useful sections. It contains uncommon theorems on the efficiency of estimates. Here efficiency is treated by means of variance inequalities for finite samples as well as from the customary asymptotic variance point of view. In his treatment of confidence regions, the author combines the traditional approach with an extended interpretation of confidence coefficients that hardly seems justified because his extension does not possess a frequency interpretation similar to that for traditional confidence coefficients.

The only other books available at about this level are those by Wilks and Kendall; however, Kendall's first volume lacks so many topics common to the other two books that it is hardly comparable. Cramér's book requires more mathematical maturity in many parts than does Wilks' book; however, in return it gives proofs of many theorems that are only stated in Wilks' book. Cramér does not cover as wide a range of topics of modern methods as does Wilks, and other topics such as the analysis of variance and normal regression theory are treated less completely. On the other hand, the dis-

cussions and illustrative examples of Cramér's book are much more complete. The exposition is clear, and there are surprisingly few misprints. Every serious student of the mathematical theory of statistics will want this book in his library.

REVIEW BY J. WOLFOWITZ
Associate Professor of Mathematical Statistics, Columbia University

THIS book by the distinguished Swedish statistician is a superb addition to the literature of statistics. It is indispensable in the library of every statistician, and its author deserves well of the statistical world.

The book is divided into three parts. The first, called mathematical introduction, discusses measure and integration theory and such miscellaneous topics as Fourier integrals, matrices, quadratic forms, and Gamma functions. It is designed to prepare the reader for what follows.

The second part discusses random variables and probability distributions. It begins with an axiomatic development based on measure theory. There follow six chapters devoted to one-dimensional chance variables. The principal properties of distribution functions are described. The normal, Poisson, Cauchy, rectangular, and related distributions are discussed in the detail needed for statistical application. The discussion and topics covered are more elementary than the author's *Random Variables and Probability Distributions* (Cambridge University Press, 1937). For example, the central limit theorem is proved under conditions no more general than Liapounoff's on the third absolute moments. Part II concludes with four chapters devoted to multidimensional chance variables. Due attention is paid the normal multivariate distribution and questions of regression and correlation.

Since the third part is the one of greatest interest to statisticians, we shall enumerate briefly the topics covered: generalities on statistical inference, characteristics of sampling distributions, asymptotic properties of sampling distributions, exact sampling distributions, tests of goodness of fit, tests of significance for parameters, classification of estimates, methods of estimation, the Neyman theory of estimation, general theory of testing statistical hypotheses, analysis of variance, and some special regression problems.

These last chapters, while delightful, are all too brief. In the preface, Professor Cramér mentions that the need to keep the volume of the book "within reasonable limits" caused omission of topics which he had originally intended to treat, such as the theory of stochastic processes, time series, and periodograms. Professor Cramér should be assured that "reasonable limits" for books as excellent as his are much greater than he modestly considers them to be, and we hope that the enthusiastic reception accorded the present book will induce the author to give us another book on the subjects thus unfortunately omitted. However, if anything had to be omitted, the present reviewer would have preferred that it not be in part III, which is unique of its kind. The material of part I, on the other hand, is already well covered in many books. Omission of part I, however, would have made the book less self-contained than it now is.

Special mention should be made of the author's style. It is lucid and pleasant, without being either terse or verbose. The scope of the material covered is very large, references are numerous and excellent, and a good bibliography is appended.

The war cut Professor Cramér off from contact with American statistics, with the result that hardly any papers published in the *Annals of Mathematical Statistics* during the war years (with perhaps two or three exceptions) are either discussed or cited in the bibliography. Neyman is well represented by his foreign publications, Wilks is represented by three papers, Hotelling by one, and Wald by none.

Comparison will inevitably be invited between Cramér's book and Wilks' *Mathematical Statistics*, which this reviewer esteems highly and has used as a textbook in his courses. However, a direct comparison would be unfair, because Wilks' book is a set of lecture notes of his courses. It covers a very wide range of topics in a small compass and is therefore very terse. However, it covers many topics not discussed or discussed only briefly by Cramér. In the reviewer's opinion the two books are complementary and not competitive. It should be a source of gratification to the Princeton University Press that both books bear its imprint.

From a book filled with gems the present reviewer chooses almost at random the following for citation: (*a*) (p. 480) Let $f(x, \alpha)$ be a density function which depends on the parameter α, and let α^* be an unbiased estimate of α from a sample of n independent observations. Under certain regularity conditions it is proved that

$$\sigma^2(\alpha^*) \geqq \left[nE\left(\frac{\partial \log f}{\partial \alpha}\right)^2\right]^{-1}.$$

(Actually the result proved is more general than we have described.) To whom this result is to be ascribed is not clear from the context. (*b*) (p. 495) Let $f(x, \alpha_1, \cdots, \alpha_k)$ be a density function which depends on the k parameters $\alpha_1, \cdots, \alpha_k$, and let a sample of n independent observations be taken. Let $\alpha_1^*, \cdots, \alpha_k^*$ be respective unbiased estimates (from the sample of n) of $\alpha_1, \cdots, \alpha_k$. Let certain regularity conditions be fulfilled, among which is that the covariance matrix $\|\lambda_{ij}\|$ of the α^*'s is nonsingular, with the inverse $\|\lambda^{ij}\|$. It is proved that the "concentration ellipsoid"

$$\sum_{i,j=1}^{k} \lambda^{ij}(u_i - \alpha_i)(u_j - \alpha_j) = k + 2$$

always contains within its interior the ellipsoid

$$\sum_{i,j=1}^{k} \mu_{ij}(u_i - \alpha_i)(u_j - \alpha_j) = k + 2$$

where

$$\mu_{ij} = nE \frac{\partial \log f}{\partial \alpha_i} \frac{\partial \log f}{\partial \alpha_j}.$$

This result is due to Cramér. (Actually the proof is only sketched out. It is given in full detail in the *Skandinavisk Aktuarietidskrift*, 29: 85–94, '46.) (*c*) (p. 424) A rigorous proof of the asymptotic distribution of the chi-square statistic for testing goodness of fit when certain parameters are estimated from the sample is given. It is assumed that the data are grouped *before* estimation, with the consequence that the methods of estimation for, say, the normal distribution, differ suggestively from the methods described in *Statistical Methods for Research Workers* by R. A. Fisher who first put this theory on a sound basis.

A conscientious regard for his duties compels the reviewer to make the following observations on three points which are such that he cannot entirely approve the author's remarks about them:

a) On pages 519 and following, the author describes a procedure for assigning a confidence coefficient to the estimation of the mean of a normal distribution whose mean and variance are both unknown, by means of an interval given *in advance of the drawing of the observations*. What the procedure is we shall not describe here. It comes after a description of the Neyman theory of estimation, but the author says, "At this point, we possibly exceed the conceptual limits of the theory as given by Neyman." Now the essence of the Neyman theory is that the method of estimation is associated with a prescribed frequency (probability) of correct decisions. No such frequency can be associated with any method of estimation by a fixed interval. As an illustration, consider an infinite sequence of samples of n on the same normal population. Professor Cramér's procedure assigns to a fixed interval an infinite sequence of corresponding confidence coefficients. Let k be any number between zero and one. We may separate the last sequence into two subsequences according as the confidence coefficient is $\leq k$ or not. Yet the frequency of correct decisions is equal in both sequences and is either zero or one. When the parameter to be estimated is considered an unknown constant and not a chance variable, it is difficult to see what nontrivial operational statistical content can be given to Professor Cramér's procedure.

b) On pages 422 and 423 and elsewhere in the book, Professor Cramér performs repeated tests of significance on the same data. Such a procedure simply enlarges the critical region and vitiates the meaning of the level of significance. It is, however, common in statistical literature.

c) On pages 457 and following, the author tests a conjecture on the data which suggested it. This procedure, to the reviewer's mind, is not in accord with the logic of induction. The hypothesis conjectured is that a certain quantity is positive. The author tests statistically the hypothesis that this quantity is zero and gets a nonsignificant result. He then concludes (p. 460) "that the conjecture suggested . . . is not supported by further analysis." What has happened here is that the data did not contradict (i.e., did not give a statistically significant result) another hypothesis incompatible with the

conjectured one. Is it fair to conclude that the data do not support the conjectured hypothesis? Actually the best estimate of the quantity in question is of course not zero, although it does not differ significantly from zero. It seems to the reviewer that the author's conclusion is justified only if the a priori evidence for the quantity's being zero is so strong that our belief in this latter hypothesis will be shaken only if the data contradict it (in a statistical sense, i.e., a significant deviation appears). However, the procedure described is widely advocated in statistical literature.

The points raised above are minor. Even if the criticism is correct, it merely illustrates the fact that it is impossible to keep a book of any size free of slips. No amount of discussion of details should be allowed to obscure the fact that Professor Cramér has given us a very valuable and excellent book.

Item-Analysis Data: Their Computation, Interpretation, and Use in Test Construction. *Frederick B. Davis* (Headquarters, Army Air Forces, Washington, D. C.). Harvard Education Papers, No. 2. Cambridge 38, Mass.: Graduate School of Education, Harvard University, 1946. Pp. v, 42. $0.75. Paper.

REVIEW BY MAX D. ENGELHART
Director, Department of Examinations, The Chicago City Colleges

ITEM analysis is the term used by constructors of educational and psychological tests to refer to the obtaining and interpreting of indices of the difficulty and of the discriminating power of the various items or exercises on an objective test. The difficulty of an item may be defined as the proportion of a sample of testees that answers each item correctly, or it may be defined as the proportion of testees that *knows* the answer to the item. Since some testees answer an objective exercise correctly as a result of chance and since not all testees attempt each item, Davis urges and explains a procedure which facilitates the obtaining of difficulty indices which correct for these conditions. If the testees in the sample are divided into a high-scoring and a low-scoring group on the basis of the total scores on the test, a given item or exercise has perfect positive discriminating power if all of the high-scoring testees answer it correctly and all of the low-scoring testees answer it incorrectly. An item has no discriminating power if the same proportions of high-scoring and low-scoring testees answer it correctly. The discrimination index is negative if a greater proportion of low-scoring testees than of high-scoring testees answers the item correctly. Occasionally test constructors use the total scores on some test other than the given one as the criterion. In this case the discrimination indices are more properly referred to as validity indices. In careful test construction the analysis may be extended to the incorrect answers of each objective exercise, since the effectiveness of exercises may be improved by revision of incorrect answers which attract a greater proportion of high-scoring testees than of low-scoring ones, or which, as is often the case, attract almost no testees at all.

A variety of discrimination indices are used by test constructors. These indices include the critical ratio, the biserial coefficient of correlation, the

product-moment coefficient of correlation, and the phi coefficient. Davis mentions the limitations of each of these indices. The critical ratio merely shows how certain one may be that an item has discriminating power. The biserial coefficient requires elaborate computation. The product-moment correlation and the phi coefficient are affected by the difficulty levels of the items. The excessive labor of computing biserial coefficients and the last limitation mentioned can be avoided by employing a procedure devised by Kelley, which involves the use of the proportions of successes on each item in the highest and lowest 27 per cents of the sample of testees and Pearson's tables, to estimate product-moment coefficients of correlation which are not essentially affected by the difficulty levels of the items. Flanagan has constructed a table of the values of such coefficients. Since, however, equal differences between coefficients of correlation of varying size do not represent equal differences in actual degrees of relationship, Davis has prepared an "Item Analysis Chart" in which the coefficients obtained by Flanagan have been first converted to corresponding values of Fisher's z and then multiplied by a constant in order to make them range from 0 to ± 100. The discrimination indices obtained from this chart are essentially comparable from item to item, because a given increase has a constant meaning in any part of the range of values and because the indices are almost entirely independent of the difficulty levels of the items. One can also obtain, through the use of certain simple formulas and the chart, difficulty indices which are estimates of the proportions of the testees in the total sample who *know* the answer to each item, since corrections are made for chance and for the variation in numbers of testees attempting each item. Davis* has reported data which show that his chart yields highly reliable item-difficulty indices and moderately reliable discrimination indices, and that the latter are independent of the former when correction is made for chance.

In addition to his notable contribution to item-analysis technique, Davis is to be highly commended for his comprehensive and scholarly discussion of the subject. He emphasizes the importance of the artistic element in test construction and adequately recognizes the limitations of item-analysis data. His treatment of the interpretation of such data must be read to be appreciated. This monograph and its accompanying "Item Analysis Chart" should be of great value to all persons who are engaged in test construction.

Statistical Quality Control. *Eugene L. Grant* (Professor of Economics of Engineering, Stanford University). New York 18: McGraw-Hill Book Co., Inc. (330 West 42nd St.), 1946. Pp. xii, 563. $5.00. *Two reviews follow:*

REVIEW BY SEBASTIAN B. LITTAUER
Professor of Mathematics, Newark College of Engineering

IT IS only natural as a result of the great impetus which has been given to the application of statistical quality control in industry that a number of

* Frederick B. Davis, "Notes on Test Construction: The Reliability of Item-Analysis Data," *Journal of Educational Psychology*, 37: 385–90, October, 1946.

of texts should be written to meet the needs of both industrial personnel and engineering students. It is further to be expected that these texts will differ in point of view, emphasis, and objective. Persons familiar with the intensive eight-day courses in statistical quality control given in the O.P.R.D. training program will recognize the pattern of presentation in this book, since those courses were modelled after the author's treatment of the subject in his teaching at Stanford University. It is clearly stated by the author that the book has been written not for the "professional statistician or mathematician" and that its objective is to establish "a general understanding of the principles underlying the various types of control charts and sampling tables." The point of view is consistently one of cost-conscious, practical application of these techniques, to which, on the whole, the subject matter is limited.

The presentation is clear and simple, and the text entirely readable. At the outset, in part 1, the reader is introduced to the concept of control and conditioned to its further study by a number of well-chosen illustrative examples. Parts 2 and 3 are devoted to control charts; part 4 to sampling acceptance procedures; and part 5 to economic and organizational considerations. Throughout the text well chosen examples buttress the exposition, giving it reality and conviction. In fact, these illustrative examples together with the many exercises which round out a number of the chapters provide valuable teaching material.

The discussion on variables charts is prefaced by a brief survey of some elementary statistical concepts, introducing the normal distribution and the distribution of sample means. Much use is made of Shewhart's material on samples of four drawn from a "normal bowl" to establish the practical usefulness of the tables of factors for determining three-sigma control limits and to exemplify a process in control, while industrial data are used to highlight processes out of control. The practical problem of initiating and administering control charts is organized into a sequence of five steps which provide the inexperienced operator with the confidence associated with a systematic procedure. By means of practical examples, bases for the selection of subgroups are aptly illustrated. Among various special adaptations of the variables charts, the use of modified control limits is exhibited.

In a section on the elements of probability, the binomial and Poisson distributions are developed preparatory to the introduction of p and c charts. Here again, the treatment is organized into basic steps and well illustrated. In the discussion of c charts, a conventional four-fold classification of defects is given. To facilitate the construction of p charts a table of three-sigma control limits for per cent defective is presented in an appendix. The treatment of control charts makes an entirely clear and comprehensive picture. It will undoubtedly be found very appealing to quality control personnel.

The presentation of acceptance sampling consists largely of an exposition of the Dodge-Romig single and double sampling plans and the "Ordnance" Tables, and the implementation of control charts in acceptance procedures.

While reference is made to the existing and forthcoming works of the Statistical Research Group on sequential and other acceptance procedures, these topics are not developed. No general classification of sampling plans is given. Some operating characteristic curves are discussed, but *OC* curves as such are not made the focus of acceptance sampling plans. The author's emphasis on the lot tolerance is open to question. He states (p. 348), "Thus it is apparent that a single figure p_t from each of a number of sampling acceptance plans gives a rough measure of their relative quality assurance throughout the entire range of possible operation." At best, the implications of this statement are misleading. The effectiveness of a sampling plan lies in its power of discrimination given by the operating ratio $R_0 = p_2/p_1$. This is the basis for the design of a number of sampling plans. In the case of the Navy sampling plans (not treated here) where choice is based on the *AQL* for a fixed producer's risk, the accompanying *OC* curve provides a measure for the power of discrimination.

The merit of acceptance criteria based upon variables inspection is considered, but sampling plans for variables inspection following from the work of Romig or that of Johnson and Welch on the non-central T, for example, are not treated. In fact, it may be considered by some a serious omission that the practical possibilities contained in these works as well as in the existing applications of Wald's sequential methods to acceptance by variables has not been brought out.

This book will unquestionably be used widely in industry both as a text and as a reference manual.

Review by L. H. C. Tippett
Statistician to the British Cotton Industry
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The methods and practice of statistical quality control have developed considerably during the recent war, and there is a large literature on the subject, which is somewhat scattered and fragmentary. There is need for a book that brings all this material together and is, in itself, a sufficient guide to the latest practice. This book goes a very long way towards meeting this need. It is fairly described as a "working manual" aimed at giving a "general understanding of the principles underlying the various types of control charts and sampling tables," and an "understanding why these methods work, how to interpret their results, and how to decide which method to use in any particular case."

There are two introductory chapters showing what the methods do, which serve to put the reader in a receptive mood, although parts of them may be too condensed for the reader who has not had previous acquaintance with the subject.

There follows a section of about 180 pages devoted to the Shewhart mean and range charts. The essential statistical ideas and calculations associated with frequency distributions are well described, a control chart for a process

in control is derived experimentally, the effects on the chart of various kinds of lack of control are shown, there are directions for making and interpreting charts, and there are many practical examples of the use of charts. Among other topics, the relation between specified tolerances and statistical variability and control is dealt with. The whole section gives a well-balanced mixture of just the right amount of statistical theory, working instructions and practical examples and advice; it is a good foundation to the book.

After a necessary chapter on probability and the binomial and Poisson distributions, control charts for the fraction defective and for the numbers of defects are briefly dealt with.

The Dodge-Romig sampling schemes, and developments of them, are described, and their application to acceptance procedures is illustrated. The superiority of procedures based on control charts is well brought out. One limitation that may be removed in future editions is the dismissal of sequential methods with little more than a mention.

One specially interesting chapter, all too short, is on the economics of quality control, showing how the costs of various control procedures should be set against the savings in manufacturing costs.

There are tables, so that the book is sufficient for the application of a wide range of the methods, although it will need to be supplemented by full tables for sampling schemes. The many examples from a wide field of industry are actual, and not "cooked" or unduly simplified; they are dealt with realistically and serve as occasions for bringing out many general points in just the kind of way they arise in practice.

Professor Grant points out some differences in practice in the U.S.A. and Britain and although he quite naturally bases his recommendations on American practice, he quite rightly does not make much of the differences. Differences that arise between two bodies of estimable and competent people do not usually amount to a row of pins.

The form of the book is open to criticism. The exposition is not entirely systematic, there is some repetition and there are too many cross references. For example, the equivalence and relative value of sigma and the range as measures of variability is a topic on its own that should, one would imagine, have been discussed once and for all in one place; in fact it is mentioned and dealt with in part in four places (pp. 105, 116, 152 and 201). And on page 439, in a chapter on acceptance procedures, there are comments on an example that refer to psychological considerations that arise in using mean and range charts for process control.

Professor Grant's essentially practical approach has undoubted merits and will appeal to many (perhaps most) of the readers he aims at, but it leads to some disorder of presentation. Had he combined his method with a more systematic presentation he could have made a shorter, better book.

A small criticism of the otherwise excellent layout is that it hardly seems necessary to disfigure the page with the heavy type of such uninformative headings as "Some Comments on Example 29."

Perhaps these points of criticism are points of personal taste; but in any event they should not be allowed to detract from our appreciation of Professor Grant's book.

An Introduction to Mathematical Genetics. *Lancelot Hogben* (Mason Professor of Zoology, University of Birmingham). New York 11: W. W. Norton & Co., Inc. (70 Fifth Ave.), 1946. Pp. xii, 260. $5.00. (London W.C.1: George Allen & Unwin Ltd. [40 Museum St.]. 25*s*.)

REVIEW BY C. W. COTTERMAN
Assistant Professor, Zoology and Assistant Geneticist
Laboratory of Vertebrate Biology, University of Michigan

THE author of *Mathematics for the Millions* here lends a helping hand to the hundreds of geneticists who have experienced difficulty in understanding the mathematical writings of a few of their colleagues. The subject of the present volume is the mathematics of Mendelian populations—an extension of those probability relationships which hold for single families to more complex problems involving whole populations. This specialized form of statistics provides a framework for mathematical theories of evolution, such as those developed by Sewall Wright, R. A. Fisher, and J. B. S. Haldane, and has already found many practical applications, notably in the genetic analysis of human populations and livestock herds. In large part, this material has not previously been summarized in book form in the English language.

The book is an expansion of a series of lectures presented to graduate students of genetics at the University of Wisconsin in 1940. It has the logical arrangement of a mathematics text and is provided with numerous exercises and answers which increase its usefulness as a manual for self-teaching. Particularly valuable in this respect are three introductory chapters on basic algebraic series, first steps in finite differences, and binomial series, in which the author gathers together various algebraic devices that have been found to be most useful in statistical genetics.

The basic parameter in Mendelian mathematics is the population "gene frequency," the proportion of all genes at a given chromosome locus which belong to one class. In the earlier chapters, the author shows how the proportions of the various genotypes or phenotypes are related to gene frequencies under a standard set of conditions, *viz.*, absence of mutation, selection, and migration, and non-assortative mating within a breeding population of unlimited size. The aforementioned chapters on algebraic method then prepare the reader for later chapters wherein the effects of altering one or more of the standard conditions are set forth. The treatment is limited to a single pair or set of genes, but sex-linked genes as well as autosomal genes are considered at each stage in the development. Careful attention is given to various concepts of selection and assortative mating and to the specification of those conditions in nature where a particular mathematical model would best apply.

It is unfortunate that the author did not apply his skill to the exposition of a wider variety of statistical methods from the works of other authors. For example, he sets forth a method which he devised for the correction of ratios derived from selected human families, but he does not correctly state its limitations, nor does he describe a more generally serviceable method due to Fisher. Indeed, none of the latter author's important contributions to statistical genetics are mentioned in the very inadequate lists of references which are provided at the ends of chapters. Metrical characters are not discussed, hence the general problems of analysis of variance and correlations between relatives are not developed. However, the very simple and widely useful coefficients of relationship and inbreeding due to Wright should at least be mentioned in an introduction to mathematical genetics, and their use would have simplified the sections on assortative mating and consanguinity.

The Advanced Theory of Statistics, Vol. II. *Maurice G. Kendall* (Statistician to the Chamber of Shipping of the United Kingdom, Bury Court, London). London W.C.2: Charles Griffin & Company Ltd. (42 Drury Lane), 1946. Pp. vii, 521. 50*s.*; abroad, including postage, 51*s.* 6*d.* (Available in the United States from Stechert-Hafner, Inc., 31 East 10th St., New York 3, at $15 per copy, less 10 per cent.)

REVIEW BY A. WALD
Professor of Mathematical Statistics, Columbia University

THE present second volume is devoted chiefly to the theory of statistical inference. It gives perhaps a more comprehensive account of the existing theory than other books published so far on this subject. Statisticians will welcome the book as a valuable addition to the existing literature.

The first four chapters, chapters 17 to 20, are devoted to the theory of point and interval estimation. The author emphasizes the difference between Neyman's theory of confidence intervals and the theory of fiducial inference as proposed by R. A. Fisher. Each of these approaches is described in a separate chapter, and the choice between the two theories is left up to the judgment of the reader. Chapters 21 to 28 deal mainly with the theory of statistical tests, including analysis of variance and regression analysis. A separate chapter is devoted to multi-variate analysis. The basic ideas of the theory of an efficient design of sampling inquiries are also discussed. Finally, the last two chapters are devoted to time series analysis, discussing particularly autoregressive schemes and periodogram analysis.

Some recent results by Cramér and Rao concerning the lower bound of the variance of an unbiased estimator are not discussed by the author. Presumably these results appeared too late for inclusion in the book. This is somewhat regrettable, since the Cramér-Rao results go beyond some of the theorems mentioned in the chapters on estimation.

In the discussion of the principal test procedures in current use, perhaps a little more emphasis could have been given to the power functions of these tests. For example, the power function of the analysis of variance tests is

only very briefly mentioned on page 302. The author discusses the asymptotic distribution of the likelihood ratio statistic when the hypothesis tested is true. It would have been useful to include also the asymptotic power function, especially since most of the test procedures in current use are likelihood ratio tests.

Some comments may be made as to the clarity, precision and rigor of the author's presentation of the material. The standards maintained in this respect are not quite so high, in the opinion of the reviewer, as would seem desirable in a book on the advanced theory of statistics. For example, on page 5 it is stated: "If, of two consistent estimators t_1 and t_2, we have var $t_1 <$ var t_2 for all n, then t_1 is more efficient than t_2 for all sample sizes." This is correct only if t_1 and t_2 are unbiased estimators. The proof of consistency of the maximum likelihood estimate, as given by the author, does not seem to be entirely complete. The proof is based on the assertion (see p. 13) that the difference between the statistics t' and t defined there can be made arbitrarily small by choosing the class intervals sufficiently small. It seems to the reviewer that the assumptions made by the author still leave the possibility open that for any choice of the class intervals there may exist values $n, x_1, \cdots, x_n$ such that $|t'-t|$ remains large, i.e. the convergence of $t'-t$ to zero is not necessarily *uniform* in $n, x_1, \cdots, x_n$. The Fisher-Cochran theorem on the distribution of quadratic forms in normally distributed variables, as formulated by the author in sections 23.4 and 23.6, is much weaker than that given elsewhere in the literature. (*See*, for example, S. S. Wilks, *Mathematical Statistics*, p. 107.) It is unclear to the reviewer how the author concludes, on the top of page 183, that $\sum_{j,k}(x_{jk}-x_{j.}-x_{.k}+x_{..})^2$ has the χ^2 distribution. This would easily follow from the identity (23.14) and the strong formulation of the Fisher-Cochran theorem as given, for example, by Wilks.

In several examples given in the chapter on analysis of variance, the author suggests the amalgamation of the high order interactions that are found nonsignificant with the residual. This is a frequently adopted procedure in practice but not always quite justifiable from the theoretical point of view and should not be done indiscriminately. First of all, the general adoption of such a rule would introduce a slight bias in the estimate of the residual variance even if the interaction in question is exactly zero in the population. The more serious objection to such a procedure perhaps is that nonsignificance of a certain interaction does not prove that the corresponding interaction in the population is really absent. Nonsignificance means merely that the sample does not give sufficiently strong evidence for the presence of such an interaction in the population. If there are strong a priori reasons to believe in the absence of the interaction under consideration, a nonsignificant result may justify the amalgamation of that interaction with the residual variance. In the absence of such a priori reasons, it would be, however, somewhat risky to rely merely on a nonsignificant result, especially if the level of significance is set as low as .05.

The criticism implied by some of the comments in the preceding paragraphs should not detract from the many other merits of the book. The author has rendered an important service to statisticians by writing such a comprehensive book on the theory of statistical inference. It contains much important and valuable material that hitherto was not available except in papers scattered over a number of journals not easily accessible. The reader will also welcome the large number of examples and illustrations given throughout the text. After each chapter a great number of interesting exercises and problems are listed. Teachers of statistics will find these exercises particularly helpful and useful in their classroom work. The author is to be highly commended for the literature references after each chapter and for the extraordinarily large bibliography at the end of the book. This will be most helpful in guiding the student to the main sources about any particular topic discussed in the book.

Contributions to the Study of Oscillatory Time-Series. *M. G. Kendall* (Statistician, Chamber of Shipping of the United Kingdom, Bury Court, St. Mary Axe, London, E.C.2). National Institute of Economic and Social Research, Occasional Papers, IX. London: Cambridge University Press, 1946. Pp. viii, 76. 7*s.* 6*d.* Paper. (New York 11: Macmillan Co. [60 Fifth Ave.], 1946. $1.75.) *Two reviews follow:*

REVIEW* BY T. W. ANDERSON

Instructor in Mathematical Statistics, Columbia University

THE main purpose of this book is to study the results of applying certain methods of times series analysis to series generated by an "autoregressive" scheme. An autoregressive scheme is defined by a stochastic difference equation

$$u_{t+2} + au_{t+1} + bu_t = \epsilon_t,$$

where u_t is a quantity observed at time t, the coefficients a and b are given numbers, and ϵ_t is a random term or "disturbance" with a given probability distribution. The author chooses four pairs of numbers a and b and, using these as coefficients, constructs four artificial times series of u_t by taking sequences of ϵ_t from random number tables. The "period" of the autoregressive scheme is taken to be the period of the solution of the difference equation, which is

$$\frac{2\pi}{\cos^{-1}\left(\frac{-a}{2\sqrt{b}}\right)}.$$

This period is estimated from each series by periodogram analysis, correlogram analysis, counting peaks, and counting "upcrosses" (a negative observation followed by a positive one). The principal conclusion is that periodogram analysis applied to an autoregressive series gives a poor estimate of the

* This review will be included in Cowles Commission Papers, New Series, No. 21.

period and furthermore gives misleading and confusing results. The last two methods do not give good estimates. In fact, in the population (i.e., infinite series) the period may be quite different from the mean distance between peaks or mean distance between upcrosses. The correlogram provides a fairly good estimate of the period, but the correlations do not damp out in an autoregressive series according to the mathematical expectation; hence, the correlogram does not necessarily indicate that the series is autoregressive. The variate difference method does not give a good estimate of the variance of the random element. Some economic time series are considered as well as the four artificial series.

The inferences drawn in the book are very interesting, but unfortunately, because of the empirical method used, are not very reliable. The four artificial series can be thought of as four observations, each from a statistical population of all series for a given a, b, and distribution of ϵ_t. One cannot have much confidence in conclusions drawn on the basis of only four observations, particularly when the problems are highly complicated. In studying some of the statistical techniques, the author does obtain the expected values of the statistics involved (or the expected values of the reciprocals), but he does not obtain indications of the sampling errors. The most significant part of the study, the effect of applying periodogram analysis of autoregressive series, needs a mathematical analysis to give definite conclusions.

In the comparison of methods it would have been instructive to consider a method designed specifically for the autoregressive model. From the maximum likelihood estimates (assuming normality of ϵ_t) of the coefficients a and b one can calculate an estimate of the period. This estimate has certain desirable statistical properties such as consistency.

The book should be educational to investigators who have applied methods such as periodogram analysis and have obtained results difficult to interpret. The author points out that the mathematical model of a finite series of trigonometric functions with a superimposed random term does not fit in economic theory well. The stochastic difference equation gives a better description of the economic process; the parameters of this model may have economic meaning. It is generally recognized that in a large number of economic time series there is no period in the sense of recurrence of phenomena after a certain exact time unit; the autoregressive model does not impose a strict period. In terms of stochastic difference equations the "period" is of secondary interest; the coefficients of the equations are the primary consideration. As the author suggests, much more mathematical statistical research is needed along this line.

REVIEW BY OSKAR MORGENSTERN
Professor of Economics, Princeton University

IN THIS paper the author endeavours to decide the adequacy of current methods of investigating oscillatory movements in time-series. The series

considered are stationary; i.e., they have no trend and their mean value is taken to be zero. Four methods of analysis are considered: (*a*) "the natural but rather crude method of measuring the average distance between peaks or between troughs" (p. 2); (*b*) harmonic or periodogram analysis (Fourier series); (*c*) correlogram analysis, based on an autoregressive period (chiefly developed by Yule and Kendall); (*d*) variate difference analysis. Each method corresponds to some idea or model of the mechanism underlying the given time series. Some of these ideas are more definite than others. The first uses few assumptions; the last, for example, assumes specifically that random elements are superimposed on a systematic movement and that the magnitude of the former can be estimated.

The model which in Kendall's opinion is most suitable to economic conditions is that of a time series subject to disturbances (which may be random) which once they have appeared are incorporated into the system and influence its further motion. This case was studied by Yule. We then have a system capable of damped oscillations but subjected to a stream of external shocks which continually regenerate the oscillations. Such a system Kendall calls autoregressive. Its study is the main objective of the brochure.

The method employed in the study is essentially experimental. Its outcome is that methods other than correlogram analysis are to be rejected, especially the periodogram analysis. To prove this, four experimental series are used, three of 240 terms, one of 480. These series embody the assumptions underlying the correlogram analysis. Use is also made of two empirical series collected by Beveridge. If the other methods are applied to the experimental series, results are obtained that have to be rejected; especially the periodogram is found to be "grossly misleading" and to have "broken down completely." The author is less emphatic regarding the rejection of the variate difference method; the procedure of counting troughs or peaks is also found wanting because of the "tendency on the part of some investigators to 'edit' the series and reject certain effects on their own judgment as unimportant."

A great amount of labor has gone into the computations, and the author is aware that much more experimentation is in order. He points out that the mechanization of computations could be carried further; part of the study concerns computational short cuts. This part of the investigation is, however, already obsolescent in view of the enormous progress in high-speed computational devices of which the author seems to be unaware, probably because of wartime restrictions of information. In the future, far more extensive calculations become a possibility than the small example which the author has computed himself. Incidentally, even at the time his work was going on, speedy machines, suited for periodograms and autocorrelations (some developed in connection with the study of encephalograms), were available which apparently were not used.

The author is particularly concerned with harmonic analysis and tries to show its inadequacy for economics. There is much to be said for this point

of view if the given series are, for example, really autoregressive; but it would have to be proved for the empirical cases. It cannot be simply assumed. There are methods, developed by N. Wiener, Kolmogoroff and others, which would have to be employed for that purpose. It is not convincing when the author merely implicitly postulates the Beveridge series to be autoregressive and dismisses their periodograms because these appear similar to those considered inadequate—obtained for his artificially constructed autoregressive series. If, however, the Beveridge series are not simply autoregressive, then in turn their correlograms may have to be rejected while, e.g., their periodograms may be acceptable. Another difficulty—recognized by Kendall—for general application of the correlogram is that short autoregressive series will not dampen sufficiently and—far worse—that the method is insensitive to changes in the scheme of autoregression. The latter becomes a real possibility in economics, especially when use is made of long series (e.g., Beveridge's), which are so highly desirable; however, these "long" series are still only short in the sense of the method; i.e., they do not tend to dampen well.

In the present phase of analysis of economic time-series, it is very difficult to state which is the best model to assume. Certainly, it is premature to decide in favor of any one, and it is risky to decide against some, especially if theories as powerful as that of the Fourier transform and integral are available and find ever increasing applications to more and more fields. Experimental work with empirically given series on an enormously larger scale than anything done thus far and with a minimum but variety of assumptions about the underlying generating mechanisms seems to be indicated. This would then also advance our theory. The reader will find the paper very well written and highly stimulating.

A Teoria da Indução Estatística. [The Theory of Statistical Induction.] *Jorge Kingston* (Professor, University of Brazil). Rio de Janeiro, Brazil: Serviço Gráfico do Instituto Brasileiro de Geografia e Estatística, 1945. Pp. 121. Paper.

REVIEW BY JOHN W. TUKEY
Assistant Professor of Mathematics, Princeton University

IN THE introduction the author quotes from Hotelling's description of the legendary Jones who wrote "another" book on statistics. With the exceptions noted below the author has avoided Jones's errors. The book is intended to serve a specific purpose, that of introducing teachers of statistics to "modern" ideas, including those of small samples. Given a sufficiently backward audience, familiar with large sample ideas and terminology, this aim should be successfully reached. If the readers are then led to consult the many well-selected references, the work will be doubly useful.

The contents of the book—the problems of theoretical statistics; significance of means and other statistics; the binomial distribution and its approximations; chi-square and goodness of fit; Student's distribution; estima-

tion and comparison of variances; analysis of variance; testing for correlation; and analysis of covariance—could serve, with slight rearrangement, as the skeleton of a broader and deeper book. The fact that 56 per cent of the pages come before Student's distribution is an indication of the space used before small sample ideas are reached. The treatment of the analysis of variance extends only through simple row-by-column tables; the analysis of covariance receives two and one-half pages.

There are few examples and some have been incautiously chosen or worded. Example 2.9A contains values supposed to be from a given normal population (unknown mean); the corresponding χ^2 is 9.51 on 3 *df*, which is near the upper 3 per cent point. This example is continued, and both confidence limits and a test of difference of means are based on this doubtful, assumed variance. Example 6.5A returns to the data of 2.9A and, miscalculating the value of s, decides that the previously significant difference is not significant and "concludes that the [material of the] sample is made of gold" —there is no attempt to discuss the difference between the failure of a test of significance to reject a hypothesis and the conclusion that the hypothesis is true. Example 7.14 draws, by mistake, the wrong conclusion from both an L_0 and an L_1 test. In both cases the observed value lies between the critical value and 1, yet both are judged significant and the samples heterogeneous.

On page 26 the author outlines a method of setting confidence limits which requires both modification in detail and rather strong auxiliary conditions, which hold in elementary cases, to be valid. On page 60, minimum expectations of 10 are recommended for χ^2, which is distinctly conservative.

In general, although spending considerable space on the effects of non-normality, the author creates the usual impression that nearly everything is normal.

Typographical errors are definitely present, but do not cause too much annoyance.

Analytic Geometry. *Francis D. Murnaghan* (Professor of Applied Mathematics, Johns Hopkins University). New York 11: Prentice-Hall, Inc. (70 Fifth Ave.), 1946. Pp. viii, 402. $3.25; to colleges, $2.60.

REVIEW BY LOUIS GUTTMAN
Associate Professor of Sociology, Cornell University

THE concept of a vector, and especially that of a matrix, is becoming of increasing importance in statistical work. A set of N observations on n variables defines an $N \times n$ matrix. Such a matrix is the basis for all linear correlation studies. When n is 2, we have simple correlation; and when n is greater than 2, we have partial, multiple, canonical, and other kinds of regression problems. All such can be thought of very conveniently in matric terms. Multivariate sampling, multiple factor analysis, various problems of quantification of qualitative data, as well as problems in time series and other fields, can be profitably and economically handled by the use of the powerful

concepts of matrices, especially with reference to bilinear and quadratic forms.

While not addressing himself particularly to students of statistics, Murnaghan has blazed a new and promising trail for them through his fresh and modern elementary textbook on analytic geometry. Using this book, rather than a traditional one covering the same material, should make it much earier to proceed to a course in statistics which deals with multivariate distributions. The notion of a vector is introduced at the outset and serves as the basis for the study of lines and planes in the first four chapters. The fifth chapter develops the ideas of determinants and matrices which are then used to study the general equation of the second degree in two and three dimensions. Murnaghan claims that "students enjoy this mode of presentation more than the traditional, rather formal method" and "are better prepared to understand their courses in physics and engineering."

In conventional courses in analytic geometry, transformation of coordinates and the study of invariants seem unnecessarily awkward when pieced out bit by bit by ordinary algebra. The use of matrices has the advantage of packaging the essentials involved into neat bundles and should make for better comprehension. From the point of view of students of statistics, the matric treatment has the further advantage of immediately generalizing to a space of any number of dimensions. There seems to be little reason for studying analytic geometry one way for a space of two or three dimensions and then another way for a space of more than three dimensions. It should prove highly useful in the future to teachers of elementary mathematical statistics, as well as of more advanced mathematical statistics, to have students come prepared with the matric algebra approach to geometry.

Opinion-Attitude Methodology. *Quinn McNemar* (Associate Professor of Psychology, Stanford University). Psychological Bulletin, Vol. 43, No. 4, July 1946, pp. 289–374, American Psychological Association, Inc., Massachusetts and Nebraska Avenues, N.W., Washington 16, D. C., $1.25.

REVIEW BY FREDERICK MOSTELLER
Lecturer in the Department and Research Associate in the Laboratory of Social Relations, Harvard University

THE paper being reviewed is essentially an 86-page monograph which attempts a critical appraisal of opinion-attitude methodology at least through 1944 (latest references seem to be early 1945). Persons interested in public opinion polling, market and consumer research, tests and measurements, attitude studies, surveys, indeed any who use the questionnaire technique, will find it stimulating reading. The author's neatly phrased and cutting criticisms might have called for duels in earlier days. Hostile critics of opinion and attitude measurement should find this paper gratifying to read and quote.

From a descriptive point of view the paper is excellent. A person unfamiliar

with methods of measuring opinions or attitudes but desirous of closer acquaintance can get a rather good picture of the various techniques and procedures. Of course a technique as complicated as factor analysis can scarcely be described in detail in such a paper—but everyday techniques such as batteries of questions, split-ballots, and equal-appearing intervals are adequately described. The author states that in preparing this paper some 800 references were examined; 133 references are included in the bibliography. Olga W. McNemar assisted with the library work.

No author is likely to escape unscathed from an attempt to criticize opinion-attitude methodology. This author will come in for an additional share of unkind remarks because of the tone he has chosen to adopt. A reader can easily get the impression that the author thinks many of his destructive criticisms are being voiced for the first time, but the reviewer cannot feel that McNemar intended to leave this impression, since it would be difficult to find an original criticism in the paper. In any case, it is a service to have this fairly exhaustive set of criticisms gathered in one place. In this connection, it might be remarked that indices for lengthy survey articles would enhance their value to the reader.

In addition to description and criticism, the author has offered some constructive suggestions for opinion-attitude methodology, and here the reviewer feels some original contributions have been made.

The paper is divided into nine sections. Section 1, Problems and Issues, outlines the field and describes the terms used. In Section 2, Attitudes by Scaling Techniques, Thurstone's method of equal-appearing intervals, problems of uni-dimensionality, rules for constructing attitude scales, "generalized attitude scales," Likert's technique, self-rating, use of criterion groups for validation, and Guttman's scaling technique are discussed. The author, in this section and others, takes a rather optimistic view of scaling in general and Guttman's method in particular, an attitude which contrasts sharply with the over-all pessimism of the paper. For example, we find on page 327 the extravagant statement, "By factorial analysis or preferably by the Guttman scaling method, uni-dimensionality can be guaranteed." Elsewhere (p. 311), "The chief merit of the method [Guttman's], which is simple in application, is that it leads to elimination of items which are not on the principal continuum, thus assuring that a single dimension is involved in the retained items." It is not pointed out that the real problems here are still thrown back into the laps of the question writers, although it is mentioned (p. 311) that "the troublesome validity problem is not solved by this 'scalogram' technique." There are numerous complaints about the paucity of reliability and validity studies. The reviewer is of the opinion that many of the best studies of validity and reliability are done by commercial organizations, and that most of them are not published because (*a*) they were not done for the benefit of academicians but for the benefit of the home organization, (*b*) they are often done as a very incidental part of studies and filed away because the client rightly or wrongly is not interested in these "de-

tails," and (*c*) commercial organizations fear with reason that their account of such studies may be garbled by critics and used against them. None of this excuses academicians for the paucity of information on reliability and validity.

Section 3, Single Question Opinion Gauging, proposes (*a*) that "*greater use be made of the open-end, nondirective, intensive interview technique*" (p. 326, author's italics) and (*b*) that "*single question opinion gauging be discarded in favor of opinion measurement by attitude scaling*" (p. 327, author's italics). The reviewer feels that scaling techniques are excellent devices, but that we can afford to do a good deal more testing before we use them wholesale. Furthermore, for many purposes the single question technique is far from being a dead horse. The single question technique is certainly a dangerous one and fraught with many uncertainties when used to estimate absolute percentages, but even at this writing it seems to the reviewer to be the technique best adapted for pursuing absolute percentages. It seems to be complete defeatism to suggest discarding single questions with the remark (p. 326) that "the chase after absolute percentages is a delusion and a snare." The author feels that the single question technique might possibly be used to get crude comparisons between groups.

It might be remarked that McNemar anticipates critics who will complain of the added cost of scale construction and schedule administration caused by rejection of the single question technique by suggesting that if the added costs are not justified "there is reason to suspect that the project isn't of much value from a rigorous scientific point of view" (p. 328). The author's general disregard of the question of costs suggests that he may not be discussing opinion-attitude methodology in general, but only as it may apply to simon-pure scientists.

In Section 4, Administration, on the basis of five studies of the selective factor in mail ballots, telephonic interviews are found to be "taboo" except for the "less scrupulous," rather a non sequitur; but the reviewer feels that there are some populations for which this mode of communication might be optimum. Indeed, mail ballots should not be so lightly cast aside either. Though mail ballots have often been badly mishandled in the past, recent investigations by L. Benson and by Hansen and Hurwicz and by others indicate that for some purposes, and under appropriate conditions, the use of mail ballots is practical, economical, and reasonably safe. We should not annihilate good cheap techniques merely because they have led others to traumatic experiences. We should profit by failures and improve methods while recognizing their limitations. Interviewing problems and types of ballots are also briefly discussed.

In Section 5, Statistical Issues, the author goes all out for "area or block sampling" as opposed to "quota sampling." The reviewer would prefer not to decide on this and related issues until he can examine the report of the staff for the Sampling Study of the Joint Committee of the National Research Council and Social Science Research Council on the Measurement of

Opinion, Attitudes and Consumer Wants. The author may not have been in a position to know of this Committee even though his work was done under a grant-in-aid from the S.S.R.C. A brief section on "erroneous statistical analysis" is included. Some common errors are discussed.

The remaining sections, entitled Study of Changes, Correlations and Interrelationships, Studies of Morale, and Concluding Remarks, will not be discussed here because of space limitations.

A few of the many excellent points that are emphasized are: (*a*) statistically significant differences may not be of practical importance and, conversely, non-significant differences are not necessarily of practical unimportance; (*b*) more work should be done on reliability; (*c*) more work should be done on validity; (*d*) too many have overlooked the problem of unidimensionality; (*e*) fewer indiscriminate breakdowns should be made; (*f*) fewer studies are needed of local college sophomores taking psychology courses and more studies of samples from which generalizations can be drawn about well-defined populations; (*g*) failure of polling agencies to predict outcome of elections does not per se mean that their sampling techniques are inadequate for opinion studies, nor vice versa; (*h*) adequate data should be presented in tables to give readers a chance to verify authors' statements (This includes sample sizes in tables of percentages.); (*i*) "considering the possibilities for determining by the experimental method the formative causes of attitudes, only the surface has been scratched" (p. 351); (*j*) the time has come when more extensive research programs with carefully conceived hypotheses should be set up and less use should be made of the shot-gun technique (which briefly described is: ask anybody everything you can think of and compute at least $n(n-1)/2$ correlation coefficients); (*k*) reduce the number of piecemeal studies; and (*l*) use more teamwork.

This paper has already had two replies. They are: Leo P. Crespi, " 'Opinion-Attitude Methodology' and the Polls—A Rejoinder," *Psychological Bulletin*, 43: 562–569, 1946; and Herbert S. Conrad, "Some Principles of Attitude-Measurement: A Reply to 'Opinion-Attitude Methodology,'" *Psychological Bulletin*, 43: 570–589, 1946.

A Simplified Guide to Statistics for Psychology and Education, Revised Edition. *G. Milton Smith* (Assistant Professor of Psychology, College of the City of New York). New York 16: Rinehart & Co., Inc. (232 Madison Ave.), October 1946. Pp. xiv, 109. $1.25. Paper. *Two reviews follow:*

REVIEW BY EDMUND CHURCHILL
Instructor in Mathematics, Rutgers University

THIS book was primarily designed for use as a supplementary text for psychology and education courses for which formal training in statistics is not prerequisite. It is perhaps difficult to write a really good book for this purpose, but the fact that Professor Smith's book consists largely of a

retelling of an old and oft-told story—the material added since the first edition was not particularly new when that edition was published—justifies our expecting a clear, sound, well-organized book.

We have, instead, a book containing more than its share of errors of fact and interpretation and which, in addition, suffers from the lack of an index, from the lack of references both to source materials and to more complete elementary discussions of the material treated here, from the author's failure to handle his illustrative data in the best fashion possible, and from a rather insipid set of exercises.

It should suffice to mention some of the book's weak points. The whole question of the acceptance of false hypotheses is largely ignored. An apparent confusion in the author's mind on this subject leads to a fallacious argument as to the interpretation of small values of chi-square (p. 89) and to dubious statements elsewhere. The null hypotheses that two samples come from populations with equal means and that they come from the same population are considered equivalent (p. 57). A group of individuals is judged to be homogeneous simply because it is not obviously heterogeneous (p. 12). The extremely dangerous suggestion is made that one can assume experimental and control groups to be similar with respect to many non-experimental factors if only they contain 50 or 100 individuals (p. 7). True, Smith says this only about "noncontrollable" factors, but the examples he uses are noncontrollable only if one insists on samples so large that proper matching becomes all but impossible. It is argued that small samples may yield misleading results (p. 6) as though this were not also true of samples of any size. The effects of "moderate amounts of skewness" are discussed (p. 16), but no guide is given anywhere as to what constitutes a moderate amount of skewness. The procedure for testing the significance of a product-moment correlation coefficient (p. 76) is faulty, and the formula for the standard error of a rank correlation coefficient (p. 74) is wrong.

This book is free from some of the errors which frequently appear in psychology-education statistics texts; nevertheless, the book is of decidedly limited usefulness.

Review by H. M. Johnson
Professor of Psychology, Tulane University of Louisiana

There is a legitimate and useful function which a good guide, or companion-book, can serve to a student of statistics—perhaps S. P. Thompson's *Calculus Made Easy* has set a pattern. Of course, to be useful, the guide must not only convey one to the place that is designated, but that destination has to be the *kind* that one seeks. For instance, a guide might conduct one by an easy road to a bog or a bed of quicksand. His guiding may have been skillful, but the destination undesirable.

The present book, however, is quite unlike Thompson's. Its purpose is largely to enable the reader to pass courses based on textbooks that are already inexact and in many respects false and misleading. In so far as it suc-

ceeds it tends to strengthen and perpetuate the superstitions which the original authors proclaimed. Its merit in this respect is otherwise a detriment to the student.

Let us, however, consider some of these superstitions.

The first one is that the Gaussian law describes "the normal, *or most common* distribution of *measures* . . . when the data are derived *from a large and unselected sample* (i.e., chosen at random, or by chance)." (The last italics are his, the others mine.) Height and weight he mentions as instances. Although a normal distribution may fit an actual distribution of some human traits throughout a limited range of experience, nevertheless, it is quite probable that because of intrinsic characteristics, the trait cannot possibly be normally distributed. Let us recall a few characteristics of a truly normal distribution: (*a*) The X-series must be continuous. (*b*) The distribution is symmetrical about the mean. (*c*) It is symmetrical about the mode. (*d*) Its range is unlimited. (*e*) The probability of a measurement falling between any pair of X-values is described within the imprecision of sampling by the Gaussian equation. (Of course this condition implies all the others.)

Let us admit that according to theory, *if* certain conditions are approximated, a distribution of *sampling-means*, of *standard deviations*, of *differences between two means* can be described and predicted on the assumption that the function in question is normally distributed. But in respect to the *original measurements* this is not generally true. Heights of men are not in fact normally distributed—nor can they be—because they cannot satisfy condition (*d*). Weights of men cannot be normally distributed because they fail conditions (*c*) and (*d*). The number n of accidents accruing to N operators in a specified number of years, miles, or operations cannot be normally distributed because it fails condition (*a*). So does the number of successes in N throws of n dice. The distribution of intelligence quotients fails conditions (*a*) and (*d*). Is it possible that the ages of human beings at death *could* be normally distributed? Is it credible that in a culture such as ours, the ages of the bridegrooms on their wedding-days could be normally distributed? Of course they aren't.

There are some traits, such as eye-dominance (which is measured by the number of times in so many chances that the subject uses his right eye for sighting), the distribution of which is U-shaped, thus failing condition (*c*), and necessarily failing conditions (*a*) and (*d*). Choice-reaction times, as I have found, fall into multi-modal distributions even when as many as 900 reactions are made with a given hand; as one of my students found, this characteristic does not smooth out when N becomes 2500.

There is a superstition, supported in this book, that if a sample population is large enough and if the measurement of the trait in question was properly made, then the distribution will approximate more and more closely to normality the larger N becomes. An example occurs in the discussion of "Grading on the Curve."

It seems to me that the student should be made to understand that for

any trait there may be *some* ideal form of distribution that is most appropriate to fit the data; that the most appropriate form can be derived from the several moments of the distribution and by the interrelations between the constant κ and the two β-constants. I would not include this among the problems to be solved in the first course, but the student should be made aware of its existence, and he should be told that it can be solved without very much labor. He should be reminded also that the normal distribution is only one among many competitors; and he should be impressed that whatever the most appropriate type may be, as one progressively enlarges the sample while holding to the original mode of sampling, the empirical results will fit the most appropriate type more and more closely, and the less appropriate types more and more loosely. And one very inappropriate type may be the normal distribution.

Indeed, it may be questioned whether this guide-book, as well as the books to which it is a guide, may not be placing far more emphasis on significances of differences between means, etc., than the subject matter justifies. A distribution is not adequately described merely by its mean coupled with its standard deviation unless we have proof that it is normal. Of course, an expert, given these two constants, could reconstruct the best fitting normal distribution in perhaps an hour, only is he likely to do it? Why not present the gross measures in a cumulative frequency table or graph, and obtain the quintile, decile, or centile scores directly? If two distributions are to be compared, present them side by side and use Pearson's test for homogeneity. My own students learn to do this in the first half of their first semester, and some educational experts rate me not very high as a teacher.

Chapter 6 deals with index-numerology. If the student is convinced by it, he believes firmly that an individual's standard scores or z-scores in two or more different traits can be added, compared, averaged, to yield a meaningful result. He may not instantly notice that each of them is a pure or abstract number, denoting exactly nothing, and that a set of such numbers however treated denotes exactly nothing—unless and until a meaning is imposed on it by correlation. It takes a good while to unteach a student who has been brought up in this superstition.

Principles of classification and of sampling receive scanty attention in this book. So does the discussion of *matching* individuals in two selected samples according to one or more traits. In fact it is not even suggested that if n traits are considered then two individuals are not really matched unless they are matched with respect to all n traits simultaneously. Of course this makes for 2^n ultimate classes, even if one merely dichotomizes according to each trait. Still, if we have 80 traits with 10 possible values of each, the number of ultimate classes is 10^{80}. But, since the traits are intercorrelated, most classes will be empty, and enough of them will contain enough members to enable us to work on them.

To summarize: although the book has merit as a guide, it nevertheless guides the reader toward acceptance of some vicious doctrines and beliefs.

The Factorial Analysis of Human Ability, Second Edition. *Godfrey H. Thomson* (Professor of Education, University of Edinburgh). London E. C. 4: University of London Press, Ltd., June 1946. Pp. xvi, 386. 20*s*. (Boston 7: Houghton Mifflin Co. [2 Park St.], 1947.)

REVIEW BY JOHN W. TUKEY
Assistant Professor of Mathematics, Princeton University

THIS book should be read by everyone interested in factor analysis, whether he is an active user or a mere bystander. To read the body of the book and to understand it, a minimum of mathematics is needed—yet the reader will learn something of all the major questions which have been debated by the factor analysts. As an example of the difficulties of interpretation which can and do arise in applying the quantitative method, it is of interest to all statisticians. As most statisticians know, the aim of factor analysis is to take the results of many individuals to a substantial number of tests, and, by algebraic manipulation, find a few "factors," such that an individual's performance, in all the tests, is well described by his "scores" on these factors. The degree of reality of the factors and the usefulness of this procedure in finding "psychological meaningful" factors are still matters of professional discussion. Thomson considers only the application of factor analysis to mental testing, and this in terms of his enduring feeling that "Far from being divided up into unitary factors, the mind is a rich comparatively undifferentiated complex of innumerable influences," yet his comments are so well-chosen and searching that they are required reading for anyone interested in any application of factor analysis or in any study of the mind.

The chief changes from the first edition are an expansion of the treatment of Thurstone's methods from one chapter to three, and the addition of a chapter on the maximum likelihood method (written by D. N. Lawley).

The book is divided into five parts: The Analysis of Tests; The Estimation of Factors; The Influence of Sampling and Selection of the Persons; Correlations Between Persons; The Interpretation of Factors. The order indicates the wisdom of the author in discussing many of the problems which do not involve sampling before bringing in its added complications. All important principles of factor analysis are discussed, but not all computational procedures.

The numerical processes outlined are based on Aitken's compact and rapid schemes.

In his third part, Thomson shows clearly how selection of the persons influences the nature of the factors found for a given battery, and points out that this makes the conventional standardization of test scores—namely, mean zero and unit variance for the particular sample used—exceedingly suspect. It is the practice of most analysts to analyze correlations, which amounts to using this standardization. (The best that has been said about standardization is that it is better than using raw scores.) Going this far, Thomson fails to take the next step, that of stating as a basic problem in this field—*How should the test results be expressed for such an analysis?* A new

principle is badly needed, and it seems to the reviewer that, when the principle is found, it will not make the mean score for each particular test and sample zero—there will be valuable information to be gained by analyzing sample means as well as the variation within samples. If this takes place, then the lack of symmetry in the interchange of persons and tests, on which Thomson comments acutely, will tend to disappear.

In his discussion of simple structure and multiple factor theories in general Thomson hints at the possibility that the experimenter may have something to do with the appearance of factors. There is nothing immoral in such an occurrence, and the whole subject deserves more study. If the experimenter is a good psychologist, in an objective sense, and if he places 17 tests in his battery which he thinks measure a "verbal factor," then he must be right, to some extent, and a suitable technique must find a "verbal factor."

This influence of the experimenter is even more important in connection with Thurstone's idea of simple structure. The psychologist develops a system of ideas about tests in a certain field—which tests are simple, what are the "pure" abilities, etc.,—composes a battery, gives it to a sample, finds a simple structure.

The sample has confirmed, quantitatively, the *consistency of the psychologist's system of ideas* and this is all. Mathematically, it is easy to construct a new system of ideas, shall we say for a Martian psychologist, which will also lead to simple structure. *The decision between these two systems cannot rest on whether or not they lead to simple structure*—it must be based on such qualitative considerations as consistency with psychological thought as a whole. The factor analysis has tested the psychologist rather than the population.

In his chapter The Sampling of Bonds, Thomson states that "the physical body has an obvious structure which guides our measurements. The mind has, comparatively speaking, no organs. We can, and do, measure it almost from anywhere to anywhere." Taking the book as a whole, it is fairly conclusively shown that this point of view cannot be proven or upset by factor analysis, hence, if it is to be upset, this must be done on more directly psychological or genetic evidence. The reviewer dares to conjecture that it will be upset.

Quality Through Statistics, Second Edition. *A. S. Wharton* (Technical Adviser Statistics, Philips Lamp Ltd.). London, W.C.2: Philips Lamp Ltd. (Century House, Shaftesbury Ave.), 1946. Pp. iv, 62. 6*s*. (Highland Park, N. J.: Gryphon Press, 1946. $1.75.)

REVIEW BY BENJAMIN EPSTEIN
Coal Research Laboratory, Carnegie Institute of Technology

THE first edition of this book was reviewed in this JOURNAL, September 1945. The differences between the first and second editions appear to be very minor. The first review can still be considered a most competent

evaluation of the book and, therefore, it seems unnecessary to give a detailed and systematic review. However, certain questions of a rather general nature arose in the mind of the present reviewer after reading the second edition, and it is these questions which will be discussed below.

In my opinion, it is regrettable that many writers on sampling—and Mr. Wharton is no exception—do not discuss the power of a sampling plan, the meaning and significance of operating characteristics, and producers' and consumers' risks. It is most unsatisfying and uninformative to write down a set of sample sizes and acceptance numbers without giving at least some indications of what the sampling plan will actually do toward rejecting or accepting a lot which is $p\%$ defective. In a sense, all one has is a skeleton devoid of flesh and blood. It is true that it may require some ingenuity on the part of writers on sampling to keep the discussion on an elementary level and yet give all the essential details, but the results will be worth the effort.

It is also the opinion of this reviewer that if Mr. Wharton is willing to go so far as to consider taking five separate random samples, with the possibility of taking another five such samples under certain conditions, then he might well consider the possibility of making his sampling sequential in character. The advantages of such a procedure are twofold: (*a*) it is rigorous from a statistical standpoint and (*b*) it would force the consideration of criteria of acceptability, nonacceptability, and risks of the first and second kind. Mr. Wharton seems to feel that shop people prefer diets unspiced with "higher mathematics." It appears that the work of the Columbia Statistical Research Group on the simplification of sequential procedures for plant use may meet Mr. Wharton's stringent criteria.

It is interesting to note that on pages 35 and 37 the author considers a problem where only a very small per cent defective can be allowed (e.g., 0.1%). Clearly, to handle such a problem requires either the taking of measurements on fairly large samples in connection with some formal control chart procedure or, as a possible alternative, work with go-not-go gauges which are set to limits so tight that a marginal lot will be expected to have as high as 5% (or perhaps 10%) defective with respect to the tighter limits (while it is still only .1% defective with respect to the full limits). The procedure is in the nature of an increased severity test and could undoubtedly be used with profit in situations where the underlying populations can be taken as normal with fairly stable standard deviations. The preliminary investigation needed to establish the validity of a procedure such as Mr. Wharton hints at may well lead to subsequent savings in the amount of sampling required to control the quality of product during production or to control the quality of incoming or outgoing lots.

A cumulative defectives chart facing page 39 showing a 5% defective line and a 10% defective line is rather interesting in that it is sequential in spirit. The chart is erroneous, and the author apparently recognizes its inadequacies by saying, among other things: "This scheme, however, is not to be recom-

mended, although it is in use in several large works. The objections to it are that it is not sensitive enough and if, after taking some 20–30 samples production gets worse, the change in the tendency will not be noticed until several samples have been taken which will mean that quite a lot of scrap may have accumulated. As the scheme does not take into consideration the laws of chance, it is unscientific and can only act as a rough guide. For some types of unskilled work, however, where some easy quality indicator is required, it may well be found useful and will be readily undestood by the works people." To put rigor into the procedure one needs to use, of course, the methods and formulae developed by A. Wald and his co-workers.

Two important points—one essentially theoretical, the other of a practical nature—seem not to have been mentioned. No discussion is given as to when one can have reasonable assurance of the existence of the state of statistical control which is necessary for some of the recommended procedures. It also seems that some consideration should be given to tool-wear trends and their effect on the determination of control limits.

It would be interesting to see how Mr. Wharton's Quality Bonus Plan would thrive in the United States. It is conceivable that it would make the amicable settling of disputes between labor and industry even more difficult and involved. It might be most embarrassing to certain people if questions were raised as to the validity of the control limits used to determine whether the worker is to receive a penalty for poor quality or a bonus for good quality or whether the fault is with the worker, the material given to him, the condition of his machine, or countless other possible sources of trouble.

In conclusion, it is the reviewer's opinion that the book represents a contribution to the literature of quality control which is valuable in the sense that it gives a reasonably uniform procedure for checking or controlling quality at various places in the production process. The book contains a wealth of practical hints, and there is little doubt that a conscientious observance of the procedures recommended (with possible modifications) and an acceptance of the author's philosophy of quality control will lead to better quality. However, it is to be regretted that the author makes it a point in more than one place to stress the need to keep the mathematics at a minimum. While it is perfectly true that he does not say that mathematical statisticians are too theoretical or too far removed from practical problems, there may be some industrial people who will read this into his statements. This would be most unfortunate since one of the hopes for progress in a field such as quality control by statistical methods is the encouragement and support on the part of large industries of fundamental work by first rate mathematical statisticians. Some of the practically important results obtained in this country by statistical research groups during the war point to the long-run wisdom and necessity of such support.

STATISTICAL METHODOLOGY INDEX, NO. 7

A QUARTERLY GUIDE TO CURRENT LITERATURE

Edited by
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Rutgers University

This bibliographic service presents statistical methodology literature (articles, books, theses, and chapters) published in 1945 to date. Anonymous references are listed first; other references follow in alphabetical sequence by first-named authors. Volume number, issue number (in parentheses), pagination, and date of issue are given for each journal reference. Stars indicate books, theses, and pamphlets; asterisks indicate publications seen by the editor of this INDEX. *Authors of papers on statistical methodology are invited to send reprints to Oscar K. Buros, Rutgers University, New Brunswick, New Jersey in order to facilitate prompt and accurate listings. Foreign-language papers should be accompanied by English translations of titles. Information is desired about references omitted.*

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